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Announcement of Opportunity

COMPLETED

HUBBLE SPACE TELESCOPE

LETTERS OF INTENT - NOVEMBER 26, 1984

PROPOSALS DUE - MAY 17, 1985

BEST COPY AVAILABLE

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LIST OF ACRONYMS

AA/OSSA	Associate Administrator for Space Science and Applications
AO	Announcement of Opportunity
AVWG	Assembly and Verification Working Group
BFL	Back Focal Length
CDR	Critical Design Review
CEI	Contract End Item
CIL	Critical Items List
Co-I	Co-Investigators
DOT	Data and Operations Team
EEF	Encircled Energy Function
EFL	Effective Focal Length
ESA	European Space Agency
EVA	Extra-Vehicular Activity
FMEA	Failure Mode and Effects Analysis
FRR	Flight Readiness Review
GO	General Observer
GSFC	Goddard Space Flight Center
HST	Hubble Space Telescope
ICD	Interface Control Document
IDT	Investigation Definition Team
IRD	Interface Requirements Document
IRN	Interface Revision Notice
M&R	Maintenance and Refurbishment
MOWG	Mission Operations Working Group
MSFC	Marshall Space Flight Center
NASA	National Aeronautics and Space Administration
ORU	Orbital Replaceable Unit
OSSA	Office of Space Science and Applications
OTA	Optical Telescope Assembly
PDR	Preliminary Design Review

PI	Principal Investigator
PRR	Preliminary Requirements Review
PSF	Point Spread Function
RMS	Root Mean Square
SA	Solar Arrays
SI	Scientific Instrument
SI C&DH	SI Control and Data Handling
SSE	Spacecraft Support Equipment
SSM	Support System Module
ST	Space Telescope
STP-G	Space Telescope Project- Goddard
ST ScI	Space Telescope Science Institute
SWWG	Software Working Group
VAP	Verification and Acceptance Program
WBS	Work Breakdown Structure

ANNOUNCEMENT OF OPPORTUNITY
FOR THE
HUBBLE SPACE TELESCOPE

I. DESCRIPTION OF OPPORTUNITY

The National Aeronautics and Space Administration (NASA) announces an opportunity to participate in future scientific investigations that use the Hubble Space Telescope (HST) observatory and require the development of flight instrumentation. The HST will be a general-purpose astronomical observatory that will be maintained in space for more than a decade. It will consist of 3 major components: the Optical Telescope Assembly (OTA); the Scientific Instruments (SI's) that employ the OTA; and the overall Support Systems Module (SSM) that supports the OTA, the SI's, and the European Space Agency (ESA)-furnished Solar Arrays (SA's).

The HST will be launched into earth orbit by the Space Shuttle. The SI's are designed as modular units that can be replaced in orbit by space-suited astronauts during subsequent visits to the HST by the Space Shuttle. This Announcement of Opportunity (AO) solicits proposals for scientific investigations that require the development of new scientific instruments as future replacements for the first complement of SI's. Issuance of this AO, however, does not constitute an obligation on the part of the Government to carry the proposed effort to completion.

Proposals for scientific investigations requiring instrumentation in either of the following categories are solicited:

- New scientific instruments different from the current instruments that expand the scientific capability of the HST
- Generically similar scientific instruments to the current SI's (see Section III.B) that include design modifications or additions to improve their observational capabilities

This AO does not represent a solicitation for General Observer (GO) science investigations utilizing either the original or some future complement

of HST instruments. The Space Telescope Science Institute (ST ScI) will announce the first opportunity to propose for such science investigations about one year prior to the launch of the HST. The HST is currently scheduled to be launched in the second half of calendar year 1986.

Proposals submitted in response to this solicitation must address the potential of the investigations that would be conducted with the proposed instrumentation and provide an adequate rationale to justify their selection. Since the incorporation of a new science instrument into the HST observatory will require the removal of one of the current instruments, an extremely strong scientific justification must be presented that demonstrates a significant expansion of the HST observatory's capabilities. Proposals in either of the above categories must also exhibit technical feasibility either within current technology or within technology that can reasonably be expected to be developed under the proposed approach and within the proposed schedule and resources.

Three to six investigations may be selected from among those received in response to this AO. Investigations from U.S. institutions will be supported by NASA to conduct investigation definition and preliminary design studies (see Attachment B, Sections 2.1 and 2.2). Each investigation definition and preliminary design study conducted will result in an updated investigation plan, an instrument and ground support equipment design specification, and a detailed flight development plan. Completion of the studies is scheduled to coincide with a review and evaluation of the in-orbit performance of the HST observatory and the onboard SI's after launch (see Attachment B, Figure B-1, Summary Schedule). Based on the results of this review and a review of the results from each study, up to three investigations will then be selected for further development (see Attachment B, Section 2.3, Phase II). The decision to proceed into this phase will also be based on the degree of each PI's commitment to performance and interface specifications, costs, schedules, and scope as demonstrated through the investigation definition and preliminary design study phase. The decision to incorporate new SI's into the HST observatory will be made by the NASA Associate Administrator for Space Science and Applications. It should be noted that this AO will constitute the only solicitation of proposals for second-generation HST science instruments.

Proposals must designate a single Principal Investigator (PI) who will be held fully responsible for implementation of the proposed efforts including: the quality of the scientific investigation and the dissemination of results, all necessary developments, timely delivery of required documentation and equipment within budget limitations, and final performance of the instruments. The PI must be supported by an appropriate team of personnel that may also include Co-Investigators (Co-I's). Each Co-I must have clearly defined responsibilities involving definition and conduct of the scientific investigations and/or development of the science instrument.

Implementation of scientific investigations associated with instruments selected for detailed design and flight development need not wait until the PI's instrument is actually incorporated into the HST observatory (see

Attachment B, Section 2.4, Phase III). In some cases where it can be clearly demonstrated that there is a need to do so, the PI may begin to expend his/her allotted observing time using any current SI following delivery and acceptance for flight of his/her instrument. An on-target observing time allotment of 350 hours is guaranteed to be scheduled for each PI by the ST ScI. This time is exclusive of the pre-operational in-orbit checkout and calibration time required when the PI's instrument is incorporated into the HST observatory. Up to 15% of the PI's guaranteed time can be utilized for necessary precursor observations with other SI's before the PI's new science instrument is incorporated into the HST observatory. Additional allocation of this guaranteed observing time may be made should there be an inordinate delay between delivery of an SI and its incorporation into the HST observatory resulting from NASA programmatic considerations. Approval for any observing time above the aforementioned 15% must be granted by the NASA HST Program Office.

Reasons for carrying out a portion of the proposed investigation using current SI's must be clearly detailed in the proposal and must be justified in terms of their value to the overall proposed science investigation. Observations which will help make the use of the new science instrument more efficient would be a good example or a reasonable use of such early observing time. Any observing time used before new science instrument incorporation into the HST observatory would be deducted from the 350 hour allotment. The remainder of this time would be spread out over a two and one half year period following in-orbit checkout. The PI will negotiate how this observing time will be apportioned with the ST ScI, but approximately 50% must be utilized in the first twelve months after in-orbit checkout. Additional observing time may be obtained competitively through the ongoing General Observer (GO) program administered by the ST ScI.

All PI's will have access to all the SI's, subject to limitations of applicable NASA policy, as will General Observers that are selected from the international astronomical community. Proprietary rights to data delivered to a PI in the conduct of his/her investigations will continue for one full year following delivery of data by the ST ScI.

The HST is conceived as a facility with substantial potential for incorporation of new instruments and new technology. Accordingly, from time-to-time additional Announcements of Opportunity will be issued soliciting investigations for the HST.

II. SCIENTIFIC OBJECTIVES OF THE HUBBLE SPACE TELESCOPE PROGRAM

Proposed scientific investigations must fall within the general scope of the HST program as outlined in this section.

The overall scientific objective of the HST program is to gain a significant increase in our understanding of the past, present, and future of the universe through observations of celestial objects and events. The broad scientific objectives of the Hubble Space Telescope Program are to determine the following.

- The constitution, physical characteristics, and dynamics of celestial entities

- The nature of processes occurring under the extreme physical conditions existing in and between astronomical objects

- The history and evolution of the universe

The HST will be unique in its capabilities and usefulness to the international science community. It represents a logical exploitation of space techniques to do the following.

- Observe the ultraviolet, visible, and infrared wavelength regions of astronomically important objects

- Achieve a spatial resolution exceeding that of ground-based observatories by a factor of ten or better

- Detect objects at visual wavelengths at least 50 times fainter than are presently observable with the largest ground-based telescopes

The following are several examples of some specific scientific objectives that are within the broader objectives stated above. This list is not intended to be all inclusive.

- Precise determination of distances to galaxies out to expansion velocities of 10^4 km/sec and calibration of distance criteria applicable at cosmologically significant distances

- Determination of the rate of deceleration of the Hubble expansion by determination of the surface brightness versus red-shift relation for distant galaxies

- Establishment of the history of star formation and nuclear processing of matter as a function of positions in nearby galaxies and determination of the variations from galaxy to galaxy

- Determination of the nature of stellar populations in the early stages of galactic evolution, based on "look-back" observation of distant galaxies

- Intercomparison of total spectra of high-red-shift quasars, low-red-shift quasars, and active galactic nuclei

- Resolution of densely-packed nuclei of globular star clusters in search of massive black holes

- Identification and flux measurement in ultraviolet and optical wavelengths of faint x-ray sources and radio pulsars

- High spatial resolution, infrared observations of proto-stars

- Direct imaging and astrometric search for planetary companions of nearby stars

- Determination of bolometric luminosities of faint, hot stars for studies of stellar evolution

- Determination of composition, temperature, density, and ionization structure of the gas in the galactic halo, in high-velocity clouds, and in the intergalactic medium

- Determination of composition of clouds in the atmospheres of Jupiter, Saturn, Uranus, and Neptune

- Resolution of surfaces of minor planets and asteroids

- Synoptic mapping of atmospheric features on Venus, Jupiter, Saturn, Uranus, and Neptune for study of atmospheric dynamics

- Intensity measurements of atomic and molecular ultraviolet emission lines important to understanding the chemistry of comets

In summary, the HST will have a capability for astronomical observations far beyond the capabilities of ground-based telescopes. With its considerable improvements in resolving power, in light sensitivity, and in wavelength coverage, it will permit scientists to resolve problems relating to the structure, the origin, the evolution, and the energy balance in the universe that could never be approached using observatories below the veil of the Earth's atmosphere. The HST will open to the astronomical sciences, and to science in a broad sense, a road to new knowledge that may help in a decisive way to shape our concept of the universe.

III. BACKGROUND - HUBBLE SPACE TELESCOPE DESCRIPTION

A. Characteristics of the HST Observatory

The HST is a high-resolution 2.4 meter telescope that will be placed in a circular Earth orbit at an altitude of approximately 590 km with an inclination of 28.5° to the equator. The telescope is an f/24 Ritchey-Chretien design with a focal plane data field 0.30 m in diameter and a central area obscuration ratio of 0.14. It will provide point-source images with 70% of the energy falling within a diameter of 0.2 arc seconds at 632.8 nm with useful sensitivity over the wavelength range of 115 nm to 1 mm. In terms of wavefront error, the minimum optical performance has been set at 0.075 λRMS as measured at 632.8 nm. This is a guaranteed minimum HST optical performance specification. The goal for image motion caused by pointing instability is 0.007 arc second RMS and is not to exceed 0.012 arc second. The characteristics of the telescope's optical system are described in more detail in Attachment E, and the optical performance data are summarized in Table E-1.

The HST is designed to allow on-orbit servicing by means of the Space Shuttle. Each of the initial SI's and many of the spacecraft subsystems are Orbital Replaceable Units (ORU's). New SI's developed as a result of this AO will be based on a modular design approach (where applicable) that should allow on-orbit replacement of critical modules as well as the entire SI. Detailed information about the design and operation of the HST is contained in the documents listed in III.D.

B. Initial Complement of Scientific Instruments

The initial complement of scientific instruments to be flown in the HST observatory includes two cameras, two spectrographs, and a photometer. In addition, the spacecraft's fine guidance sensors will be used to obtain precise astrometric data. The basic capabilities of these instruments are summarized briefly below. A more thorough description may be found in Leckrone, David S., Publications of the Astronomical Society of the Pacific, Vol. 92, Feb. 1980, p. 5.

Wide Field and Planetary Camera (WF/PC)

PI:	J.A. Westphal/CIT
Wavelength Range:	1,150-11,500 angstroms
Field of View:	Wide Field Mode - 2.67 arc min Planetary Mode - 1.15 arc min
Angular Pixel Size:	Wide Field Mode - 0.10 arc sec Planetary Mode - 0.043 arc sec
Auxiliary Modes:	Objective Grating, Polarimetry
Detector:	CCD's
Active Focus:	Yes

Faint Object Camera (FOC)

PI:	F. Macchetto/(Leader, ESA FOC Investigation Definition Team)
Wavelength Range:	1,150-7,000 angstroms
Field of View:	High Resolution Mode - 11 arc sec Low Resolution Mode - 44 arc sec
Angular Pixel Size:	High Resolution Mode - 0.022 arc sec Low Resolution Mode - 0.088 arc sec
Auxiliary Modes:	Imaging Spectrograph, Coronograph, Polarimeter
Detector:	Image Intensifier + SIT Tube
Active Focus:	Yes

Faint Object Spectrograph (FOS)

PI:	R.J. Harms/UCSD
Wavelength Range:	1,150-8,500 angstroms
Field of View:	Aperture limited, 0.1-4 arc sec
Spectral Resolution:	$\lambda/\Delta\lambda = 10^3$ and 10^2

Faint Object Spectrograph (FOS) (cont)

Auxiliary Modes:	Spectropolarimetry, Time-Resolved Spectrophotometry
Detector:	Digicons
Active Focus:	No

High Resolution Spectrograph (HRS)

PI:	J.C. Brandt/GSFC
Wavelength Range:	1,100-3,200 angstroms (includes solar-blind capability)
Field of View:	Aperture limited, 0.25-2 arc sec
Spectral Resolution:	$\lambda/\Delta\lambda = 10^5$, 10^4 and 10^3
Auxiliary Modes:	Time-Resolved Spectrophotometry
Detector:	Digicons
Active Focus:	No

High Speed Photometer (HSP)

PI:	R.C. Bless/University of Wisconsin
Wavelength Range:	1,200-6,600 angstroms (primary mode)
Field of View:	Aperture limited, 0.4-1 arc sec
Minimum Integration Time:	10 μsec
Auxiliary Modes:	Ultraviolet Polarimetry, Occultation Photometry
Detectors:	Image Dissector Tubes, Photomultiplier
Active Focus:	No

Astrometry (Fine Guidance Sensors)

PI:	W.H. Jefferys/University of Texas
Wavelength Range:	4,700-6,900 angstroms
Positional Accuracy:	2 milliseconds of arc for 3 or more stars in a single field of view
Magnitude Range:	10-17 m_v
Rate of Measurement:	10 stars in 10 minutes at 17 m_v
Photometric Accuracy:	1%

C. IR Capability

Although a cryogenically cooled infrared instrument was not included in the initial complement of HST SI's, the intrinsic capability of the HST as an uncooled, large-aperture telescope to accommodate an IR instrument has been preserved. An HST Infrared Performance Study Report (see Applicable Documents listed in III.D) described (a) stray light performance for a 45 degree off-axis source, (b) the focal plane flux intensity due to self-emission of the telescope for steady-state thermal conditions, slew conditions, and orbital variations, (c) the effects of the thermal control system heaters on flux

intensity, and (d) the effects of self-emissions of the SI's on flux intensity. Performance predictions are also provided at 4 IR wavelengths along with information for IR flux computation at any other wavelength of interest.

D. Applicable Documents

The following documents are applicable to this AO. In the event of conflict between any of these documents and the contents of this AO, the contents of this AO shall control.

Title	Document Number	Latest Revision	Date
SI to OTA & SSM IRD	STR-02C	IRN 55	7/1/81
Axial SI to OTA & SSM ICD	ST-ICD-02D	IRN 60	12/27/82
Radial SI to OTA & SSM ICD	ST-ICD-03E	IRN 39	11/18/82
SI to SI C&DH ICD	ST-ICD-08D	IRN 15	7/22/80
VAP Performance Verification Plan	STSOP-VAP-0101	Change #2	8/31/82
SSM/ST Weight Control Plan	SE-19 Rev. C	--	10/31/80
ST Electrical Power Control Plan	SE-17 Rev. E	--	10/31/80
ST On-Orbit Maintenance Mission Space Support Equipment Design and Performance Requirements	MSFC-RQMT 691.2	--	8/82
ST Mission Operations Functional Requirements	SMO-1000, Rev. C	--	1/84
Safety Policy and Requirements for Payloads Using the Space Transportation System (STS)	NHB 1700.7A	--	12/9/80
Reliability Program Provisions for Aeronautical & Space Systems Contr.	NHB 5300.4(1A)	--	4/70
STP-G Follow-On Instrument Flight Assurance Requirements	None	--	6/84
Implementation Procedure for STS Payloads System Safety Reqmts.	JSC 13830	--	5/79

Title	Document Number	Latest Revision	Date
ST Command List	DM-01G	--	3/5/84
ST Instrumentation Program and Component List	DM-02H		3/5/84
ST Operations Constraints and Restrictions	SMO-1020A (ST/SE-34)	--	1/20/84
ST Infrared Performance Study Final Report	ST-3482-80A (PR-536A)	--	6/81
Preliminary Operations Requirements and Test Support (PORTS) CEI Spec.	STE-09 (S-511-4)	--	4/81
Guide Star Selection System (GSSS) CEI Spec.	STE-10	--	3/1/81
Preliminary Criteria for the Fracture Control of the Space Shuttle Structures	NASA SP-8095	--	6/71
Science Operations Ground System (SOGS) CEI Spec.1	STE-13A	Change #12	3/82
Payload Operations Control Center(POCC) Applications Software Support (PASS) CEI Spec.	STE-14 (S-503-2)	--	12/81
ST Data Capture Facility Functional Requirement	SE-01	--	3/81
ST ScI Data Analysis Software Functional Spec.	STE-16	SCN #1	2/11/81
ST Design Reference Mission	SE-01B (LMSC/D613561B)	--	3/2/82
ST ScI Science Operations Concepts	SO-07B Part 1 + Rev. B1 Part 2	--	5/6/83
SI Thermal Analysis for Space Telescope (Data Book III)	LMSC/D799286	--	7/31/81
Structural Strength Program Requirements	MSFC-HDBK 505A	--	1/81

Title	Document Number	Latest Revision	Date
Hubble Space Telescope Level 1 Requirements	NASA HQ CSSA	--	12/23/83
The Space Telescope Scientific Instruments, David S. Leckrone, Publications of the Astronomical Society of the Pacific, Vol. 92, No. 545, Feb. 1980.)			
Special Requirements and Data Policy for Second Generation Scientific Instruments	MSFC Memorandum EE61 (56-84)	--	2/84

The latest applicable versions of the Interface Revision Notices (IRN's) to the ST ICD's referenced in this AO are listed in the latest contractual issue of the ST Interface Control Document Contractual Index and Status Report, SCM-2000. All documents will be sent to each prospective PI upon receipt of his/her Letter of Intent to propose (see VI.A) and will also be available for inspection at the preproposal briefing.

IV. REQUIREMENTS AND CONSTRAINTS

A proposal must establish the scientific merit of the investigation proposed. Since a proposal that is responsive to the stated objectives of this AO could ultimately entail the definition, design, development, and application of space flight and ground support equipment and instrumentation, it must adequately address the technical feasibility of the approach and the reasonableness of the efforts required within the proposed budget and schedule.

New HST scientific instruments will be designed and developed within the framework of a tightly cost-controlled program. The phases of SI definition, design, development, delivery, and acceptance testing must be completed according to the schedule in Attachment B, Scientific Instrument Management Plan. It is imperative that proposers establish and maintain a credible low-cost approach and schedule throughout the development of flight-quality instruments and support hardware.

It is expected that the HST and its ground system will evolve during on-orbit operations. Since a new HST SI must be designed to be compatible with the observatory and its ground system, at least three factors expected to evolve in time should be kept in mind: (1) the likelihood that onboard memory usage in the DF-224 and the NSSC-1 computers will increase substantially--therefore, the demands that a new SI will place on these memories should be minimal; (2) the likelihood that on-orbit internal adjustment of instrument

focus (and perhaps other adjustments of the SI optical train) may be necessary to optimize performance; and (3) the likelihood that the HST flight and ground software and the command lists in use at launch may alter significantly as on-orbit experience is gained. Therefore, there should be sufficient flexibility in the SI hardware, firmware, and software designs to accommodate such changes.

V. PROPOSAL EVALUATION AND SELECTION PROCESS

A. Evaluation of Proposals

Proposals received in response to this AO will be evaluated in accordance with the provisions of NASA NHB 8030.6 - Guidelines for Acquisition of Investigations. Accordingly, all proposals will be reviewed by a peer group of scientists. The purpose of the review is to assess the scientific merit and soundness of the proposals within the context of this AO. This review will involve evaluating the proposals with respect to the general criteria in Section V.B. Note specifically that proposals may be evaluated by a contractor selected by NASA. The contractor will evaluate the scientific and technical strengths and weaknesses of each proposal and will provide the NASA Headquarters ST Program Office with a report summarizing these strengths and weaknesses. Proposals judged to have the greatest scientific merit will be reviewed further by the GSFC and MSFC project offices with respect to the specific criteria listed in Section V.C. The NASA Associate Administrator for Space Science and Applications will make the final selections on the basis of these reviews, the programmatic recommendation of appropriate NASA Headquarters Offices, and the recommendations of the Space Science and Applications Steering Committee (SSASC). Peer evaluation may also be utilized to aid in the evaluation process that will precede the detailed design and development phase (see Attachment B, Section 2.0).

B. General Criteria Used in All Selections

The identification of unique ideas and capabilities best suited to the overall scientific and technological objectives of the HST program is a fundamental aim of the investigation acquisition process. Hence, the following general criteria will be used in all selections. These criteria are listed in priority order.

- o The overall scientific merit of the proposed investigation, including the desirability of the investigation within the discipline to which it pertains and the probability of acquiring new scientific results as compared to those expected from the original complement of Space Telescope Science Instruments

- o The responsiveness to the AO objectives and the relevance to the established mission objectives

- o The compatibility with the observational capabilities of the HST

- o The competence and relevant experience of the PI and other team members as an indication of their ability to carry the proposed investigation and SI development to a successful conclusion

- The technological merit of whatever apparatus is proposed with particular regard to its ability to supply the data needed for the investigation

C. Specific Criteria

In addition to the general criteria listed above, the following specific criteria will be applied in evaluating the proposals. Cost and management factors (e.g., proposed small business participation in instrument fabrication or investigation support) will also be considered in all cases. The following specific evaluation criteria are listed in rough order of priority.

- The soundness of the engineering approach and the current state of development of technology required for the proposed instrumentation hardware and design
- The compatibility of the proposed instrument design with the HST program requirement that all HST SI's be orbital replaceable units
- The suitability of the proposed SI for a modular design to enable on-orbit replacement of as many critical subsystems as possible
- The costs expected to bring the investigation to a satisfactory completion and adherence to good management practices as exhibited in the management plan
- Institutional resources available and degree of commitment to assure that the proposed investigation can be successfully completed

VI. PREPROPOSAL ACTIVITIES

A. Letters of Intent to Propose

Investigators planning to propose in response to this solicitation should submit a Letter of Intent (two-page maximum) to the HST Program Scientist with a copy to the HST Instruments Scientist. The Letter of Intent should be received on or before November 26, 1984, at the following addresses:

Dr. Edward J. Weiler HST Program Scientist Code EZ-7 NASA Headquarters Washington, DC 20546 USA	Dr. David S. Leckrone HST Instruments Scientist Code 681 Goddard Space Flight Center Greenbelt, MD 20771

The Letter of Intent should include the proposer's name, address, and telephone number; the name of the sponsoring organization; and a list of any anticipated Co-I's along with their respective institutions. A brief summary should be included that outlines the science investigation and describes the technical approach proposed to develop the capability to achieve the science goals. Material in the Letter of Intent is for information only and is not binding on the signatories.

B. Preproposal Briefing

A preproposal briefing will be held at the Goddard Space Flight Center, Greenbelt, Maryland, on Tuesday, December 11, 1984. Notification of the time and location and an agenda for the briefing will be sent to all those who have submitted a Letter of Intent. Each proposer should notify Dr. Leckrone in writing of the number of people from his/her team who plan to attend the preproposal briefing. There will be no restriction on the number of people. This notification is due two weeks prior to the briefing. Specific questions should be submitted in writing to Dr. Leckrone at least two weeks prior to the briefing to allow for the preparation of replies.

VII. PROPOSAL SCHEDULE

Letter of Intent: due not later than November 26, 1984
Preproposal Briefing: December 11, 1984
Proposals Due: May 17, 1985
Initial Selection: October 15, 1985

VIII. PROPOSAL PREPARATION INFORMATION

The following guidelines apply to the preparation of proposals by potential investigators in response to this AO. The material presented below is a guide for the prospective proposer, and not intended to be all encompassing or directly applicable to the various types of proposals which can be submitted. The proposer should provide adequate information relative to those items applicable or as otherwise required by this AO.

Proposals should contain a clear and complete description of the proposed investigation and how it will contribute to the overall science objectives of the HST program. The proposal should contain adequate background to be meaningful to a qualified reviewer generally familiar with the field, but not necessarily a specialist. The roles and responsibilities of each Co-Investigator must be specified.

The proposal is to be submitted in three separate parts: a Scientific Investigation and Technical Proposal; a Management Proposal; and a Cost Proposal. Thirty (30) copies of each are required. A dated letter or cover page should be attached to one copy of each part that is signed by the Principal Investigator and an institutional official authorized to certify institutional support, sponsorship of the investigation, management, and financial aspects of the proposal. The cover of each copy should include a short descriptive title for the investigation; the full names of the Principal Investigator and any Co-Investigators with their complete mailing address and telephone number; and the complete name and address of the responsible organization or institution. The proposal should contain a table of contents. General instructions and provisions for proposers are provided in Attachment A. Foreign proposers should refer to section IX. Domestic proposals should be sent to:

National Aeronautics and Space Administration
Office of Space Science and Applications
Attn: Code EPM-20 (AO No. OSSA-4-84)
Washington, DC 20546

A. Investigation and Technical Proposal

The investigation and technical proposal should consist of a main body and optional appendices. The main body should be limited to eighty (80) pages including illustrations and should contain no more than two (2) fold-out pages. It should be single-spaced and typewritten without reduction. Appendices may be used to clarify technical details and to expand on the background and qualifications of the Principal Investigator and Co-Investigators having roles and responsibilities clearly defined in the main body. It should be noted, however, that reviewers of the proposal are not required to utilize information in Appendices. Thus all pertinent information necessary for a sound scientific and technical assessment of the proposed investigation must be contained in the eighty pages or less of the main body of the proposal.

The investigation and technical proposal should contain at least the following. Attachment C provides a more detailed outline of the information which will be useful in evaluating your proposal.

(1) Summary. A concise statement of the investigation to be conducted, the general approach to be followed and the results anticipated.

(2) Objectives and Significant Aspects. A brief definition of the objectives, their value, and their relationship to past, current, and future efforts. The background and basis for the proposal and a demonstration of the need for such an investigation in terms of the recognized capabilities of the current HST SIs. A statement of present development in the discipline field and the contribution to be expected from the proposed investigation.

(3) Investigation Approach. A full description of the concept of the investigation and detailed method and procedures for carrying out the investigation.

(4) Instrument. This section should describe information necessary for the experiment definition, design, development, integration, ground operations, and flight operations. This section must be complete in itself without need to request additional data. Failure to furnish adequate data may preclude evaluation of the proposal.

a. Instrument Characteristics. This section should provide a conceptual description of the instrument and indicate items which are proposed to be developed as well as any applicable existing instrumentation. Performance characteristics should be related to the experiment objectives as stated in the proposal. A table summarizing at least the following instrument parameters should be included:

a) Spectral range
b) Spectral resolution if applicable
c) Field of view

d) Spatial resolution
e) Temporal resolution
f) Photometric characteristics

b. Instrument Description. This section should describe the parameters of the instrument pertinent to the accommodation of the instrument in the spacecraft. These include, but are not limited to, preliminary estimates of the volumetric envelope; weight; power requirements; thermal requirements; telemetry requirements; sensitivity to or generation of contamination (e.g., EMI, gaseous effluents); data processing requirements; active focus provisions, if applicable; compatibility with a modular design; and on-orbit repair objectives.

c. Ground Operations. This section should identify potential unique requirements for prelaunch or postlaunch ground operations support.

d. Flight Operations. This section should identify any requirements for flight operations support including mission planning. Operational constraints, viewing requirements, and pointing requirements should also be identified. Details of communications and tracking needs should be delineated. Special communications facilities that are needed must be described. Describe real-time ground support requirements and indicate any special equipment or skills required of ground personnel.

(5) Data Reduction and Analysis. This section should contain a discussion of the data reduction and analysis plan including the method and format. In the case of the Hubble Space Telescope program, the ST ScI will be the final repository of all raw and calibrated observational data.

B. Management Proposal

The management proposal should summarize the management approach and the facilities and equipment required. Attachment D provides additional guidelines for preparing this proposal.

1. Management

a. The management proposal sets forth the investigator's approach for managing the work, the recognition of essential management functions, and the overall integration of these functions.

b. The management proposal gives insight into the organization proposed for the work, including the internal operations and lines of authority with delegations, together with internal interfaces and relationships with NASA, major subcontractors, and associated investigators. Likewise, the management proposal usually reflects various schedules necessary for the logical and

timely pursuit of the work accompanied by a description of the investigator's work plan and the responsibilities of the Co-Investigators.

c. The proposal should describe the proposed method of instrument acquisition. Specifically, it should include the following, as applicable:

(1) Rationale for the investigator to obtain the instrument through or by the investigator's institution.

(2) Method and basis for the selection of the proposed instrument fabricator.

(3) Unique or proprietary capabilities of the instrument fabricator that are not available from any other source.

(4) Contributions or characteristics of the proposed fabricator's instrument that make it an inseparable part of the investigation.

(5) Availability of supporting personnel in the institution to successfully administer the instrument contract and technically monitor the fabrication.

(6) Status of development of the technology needed for the instrument. What additional development is needed. Areas that need further design or in which unknowns are present.

(7) Method by which the investigator proposes to:

(a) Prepare instrument specifications.
(b) Review development progress.
(c) Review design and fabrication changes.
(d) Participate in testing program.
(e) Participate in final checkout and calibration.
(f) Provide for integration of instrument.
(g) Support postlaunch SI performance verification and calibration.
(h) Coordinate with Co-Investigators, other related investigations, and the payload integrator.
(i) Assure safety, reliability, and quality.

(8) Planned participation by small and/or minority business in any subcontracting for instrument fabrication or investigative support functions.

2. <u>Facilities and Equipment</u>

All major facilities, laboratory equipment, and ground-support equipment (GSE) (including those of the investigator's proposed contractors

and those of NASA and other U.S. government agencies) essential to the experiment in terms of its system and subsystems are to be indicated, distinguishing insofar as possible between those already in existence and those that will be developed in order to execute the investigation. The outline of new facilities and equipment should also indicate the lead time involved and the planned schedule for construction, modification, and/or acquisition of the facilities.

C. Cost Proposal (U.S. Investigations Only)

The cost proposal must summarize the estimated total investigation cost for all three phases described in Attachment B both by level 2 WBS elements (see Figure D-1) and by the following major categories of cost. Also note information on Cost Proposal Certification provided in Attachment A, Section 5.0. Additional guidelines for preparing the cost proposal are provided in Attachment D.

The categories of cost should include the following:

1. Direct Labor. List by labor category, with labor-hours and rates for each. Provide actual salaries of all personnel and the percentage of time each individual will devote to the effort.

2. Overhead. Include indirect costs which, because of their incurrence for common or joint objectives, are not readily subject to treatment as direct costs. Usually these are in the form of percentages of the direct labor costs.

3. Materials. This should give the total cost of the bill of materials including estimated cost of each major item. Include lead time of critical items.

4. Subcontracts. List those over $25,000, specify the vendor, if known, and the basis for estimated costs. Include any baseline or supporting studies.

5. Special Equipment. Include a list of special equipment with lead and/or development time.

6. Travel. List estimated number of trips, destinations, duration, purpose, number of travelers, and anticipated dates.

7. Other Costs. Costs not covered elsewhere.

8. General and Administrative Expense. This includes the expenses of the institution's general and executive offices and other miscellaneous expenses related to the overall business.

9. Fee (if applicable).

IX. FOREIGN PROPOSALS

Proposals from individuals outside the United States should be submitted in English and in the same format (excluding cost plans) as U.S. proposals. Letters of Intent to propose should be sent directly to the HST Program Scientist at the address in VI.A with a copy to:

National Aeronautics and Space Administration
International Affairs Division
Attn: LID (OSSA-4-84)
Washington, DC 20546
USA

Foreign proposers must have their proposal reviewed and endorsed by the appropriate governmental agency. The endorsed copy of the proposal should be sent to the International Affairs Division at the address given above and arrive before the deadline for receipt of proposals.

Thirty advance copies of the proposal should also be sent directly to the HST Program Scientist at the address in VI.A and arrive before the deadline for receipt of proposals under VII.

All other correspondence from foreign proposers and organizations should be sent to NASA's International Affairs Division. Foreign proposals will go through the same evaluation and selection process as U.S.-originated proposals. Should a foreign proposal be selected, NASA will arrange with the sponsoring agency for participation on a cooperative (no-exchange-of-funds) basis, in which NASA and the sponsoring agency will each bear the cost of discharging its respective responsibilities, including travel and subsistence for its own personnel.

The Hubble Space Telescope is the cornerstone of the NASA Space Astronomy Program for the next decade. With its greater than an order of magnitude increase in both sensitivity and spatial resolution over current optical ground-based facilities, the HST will make enormous advances possible in our understanding of phenomena within our solar system, our galaxy, and to the very limits of the universe. I invite you to participate in this important and exciting program.

B I Edelson

B. I. Edelson
Associate Administrator for
Space Science and Applications

Attachments

ATTACHMENT - A

GENERAL INSTRUCTIONS AND PROVISIONS

1.0 INSTRUMENTATION AND/OR GROUND EQUIPMENT

By submitting a proposal, the investigator and institution agree that the NASA has the option to accept all or part of the offeror's plan to provide the instrumentation or ground support equipment required for the investigation or the NASA may furnish or obtain such instrumentation or equipment from any other source as determined by the selecting official. In addition, the NASA reserves the right to require use, by the selected investigator, of Government instrumentation or property that subsequently becomes available, with or without modification, that will meet the investigative objectives.

2.0 TENTATIVE SELECTIONS, PHASED DEVELOPMENT, PARTIAL SELECTIONS, AND PARTICIPATION WITH OTHERS

By submitting a proposal, the investigator and the organization agree that the NASA has the option to make a tentative selection pending a successful feasibility or definition effort. NASA has the option to contract in phases for a proposed experiment, and to discontinue the investigative effort at the completion of any phase. The investigator should also understand that NASA may desire to select only a portion of the proposed investigation and/or that NASA may desire the individual's participation with other investigators in a joint investigation, in which case the investigator will be given the opportunity to accept or decline such partial acceptance or participation with other investigators prior to a NASA selection. Where participation with other investigators as a team is agreed to, one of the team members will normally be designated as its team leader or contact point.

3.0 SELECTION WITHOUT DISCUSSION OR AFTER LIMITED DISCUSSION

The Government reserves the right to reject any or all proposals received in response to this Announcement when such action shall be considered in the best interest of the Government. Notice is also given of the possibility that any selection may be made without discussion or after limited discussion. It is therefore emphasized that all proposals should be submitted initially on the most favorable terms that the offeror can submit.

4.0 HARDWARE FLIGHTWORTHINESS

By submitting a proposal, the investigator and the investigator's institution understand that proposals selected involving flight experiment hardware will be required to comply with flight mission flightworthiness requirements. This must be accomplished by the organization managing the acquisition of the hardware. Flightworthiness requirements will be those that ensure necessary flight safety, and those that ensure a reasonable probability

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of satisfactory mission performance of the experiment hardware (reliability and quality assurance). Specifics of these requirements will vary from program to program. Investigators selected to provide experiment hardware will be advised of the pertinent flightworthiness requirements for the mission and experiment in a timely manner by the NASA Contracting Officer.

5.0 STATUS OF COST PROPOSALS (U.S. PROPOSALS ONLY)

The investigator's institution agrees that the cost proposal submitted in response to the Announcement of Opportunity (AO) is for proposal evaluation and selection purposes, and that, following selection and during negotiations leading to a definitive contract, the institution will be required to resubmit or execute a Department of Defense Form 633 (Contract Pricing Proposal), as well as submitting all certifications and representations required by law and regulation.

6.0 TREATMENT OF PROPOSAL DATA

The following will apply in the treatment of proposal data received in response to this Announcement:

a. Commercial and Financial Data

(1) It is NASA's policy to use commercial and financial data included in proposals for evaluation purposes only. This policy does not require that this kind of proposal data bear a notice.

(2) Where it is the practice of an offeror or proposed subcontractor to treat certain commercial and financial data as a trade secret, and such data is protectible as a trade secret under law, that offeror may apply the "Notice" of paragraph (b) below to those portions to be maintained as a trade secret.

(3) In any event, commercial and financial data submitted to NASA in a proposal will be protected to the extent permitted under the law, either as a properly noticed trade secret, or as commercial or financial information received from a person and considered confidential or privileged.

b. Technical Data. It is NASA's policy to use the technical data contained in any proposal submitted in response to this Announcement for evaluation purposes only. Where any of such technical data constitutes a trade secret under the law and the offeror, or potential subcontractor, desires to maintain trade secret rights in such technical data, the following "Notice" must be affixed to the cover sheet of the proposal specifying therein the pages of the proposal which contain trade secrets to be restricted in accordance with the conditions of the "Notice."

Thereafter it is NASA policy to protect such noticed technical data as a trade secret. NASA assumes no liability for use or disclosure of any proposal technical data to which the "Notice" has not been applied.

NOTICE

Data on page ---- of this proposal constitute a trade secret. It is furnished to the Government in confidence with the understanding that it will not, without permission of the offeror, be used or disclosed other than for evaluation purposes; provided, however, in the event a contract is awarded on this proposal, the Government may obtain in the contract additional rights to use and disclose this data.

7.0 LATE PROPOSALS

The U.S. Government reserves the right to consider proposals or modifications thereof received after the date indicated for such purpose, but before award is made, should such action be in the interest of the Government.

8.0 DISCLOSURE OF PROPOSALS OUTSIDE GOVERNMENT

NASA may find it necessary to obtain proposal evaluation assistance outside the Government. Where NASA determines it is necessary to disclose a proposal outside the Government for evaluation purposes, arrangements will be made with the evaluator for appropriate handling of the proposal information. Therefore, by submitting a proposal the investigator and institution agree that NASA may have the proposal evaluated outside the Government. If the investigator or institution desire to preclude NASA from using an outside evaluation, the investigator or institution should so indicate on the cover. However, notice is given that if NASA is precluded from using outside evaluation, it may be unable to consider the proposal.

9.0 EQUAL OPPORTUNITY (U.S. PROPOSALS ONLY)

By submitting a proposal, the investigator and institution agree to accept the following clause in any resulting contract:

EQUAL OPPORTUNITY (JUNE 1973)

During the performance of this contract, the Contractor agrees as follows:

1. The Contractor will not discriminate against any employee or applicant for employment because of race, color, religion, sex, or national origin. The Contractor will take affirmative action to ensure that applicants are employed, and that employees are treated during employment, without regard to their race, color,

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religion, sex, or national origin. Such action shall include but not be limited to the following: Employment, upgrading, demotion, or transfer, recruitment or recruitment advertising; layoffs or termination; rates of pay or other forms of compensation; and selection for training, including apprenticeship. The Contractor agrees to post in conspicuous places, available to employees and applicants for employment, notices to be provided by the Contracting Officer setting forth the provisions of this nondiscrimination clause.

2. The Contractor will, in all solicitations or advertisements for employees placed by or on behalf of the Contractor, state that all qualified applicants will receive consideration for employment without regard to race, color, religion, sex, or national origin.

3. The Contractor will send to each labor union or representative of workers with which the contractor has a collective bargaining agreement or other contract or understanding, a notice to be provided by the agency Contracting Officer, advising the labor union or workers' representative of the Contractor's commitments under this nondiscrimination clause and shall post copies of the notice in conspicuous places available to employees and applicants for employment.

4. The Contractor will comply with all provisions of Executive Order 11246 of September 24, 1965, as amended by Executive Order 11375 of October 13, 1967, and of the rules, regulations, and relevant orders of the Secretary of Labor.

5. The Contractor will furnish all information and reports required by Executive Order 11246 of September 24, 1965, as amended by Executive Order 11375 of October 13, 1967, and by the rules, regulations, and orders of the Secretary of Labor or pursuant thereto, and will permit access to the contractor's books, records, and accounts by the contracting agency and the Secretary of Labor for purposes of investigation to ascertain compliance with such rules, regulations, and orders.

6. In the event of the Contractor's noncompliance with the Equal Opportunity clause of this contract or with any of the said rules, regulations, or orders, this contract may be cancelled, terminated, or suspended, in whole or in part, and the Contractor may be declared ineligible for further Government contracts in accordance with procedures authorized in Executive Order 11246 of September 24, 1965, as amended by Executive Order 11375 of October 13, 1967, and such other sanctions may be imposed and remedies invoked as provided in Executive Order 11246 of September 24, 1965, as amended by Executive Order 11375 of October 13, 1967, or by rule, regulation, or order of the Secretary of Labor, or as otherwise provided by law.

7. The Contractor will include the provisions of Paragraph (1) through (7) in every subcontract or purchase order unless exempted by rules, regulations, or orders of the Secretary of Labor issued pursuant to Section 204 of Executive Order 11246 of September 24, 1965, as amended by Executive Order 11375 of October 13, 1967, so that such provisions will be binding upon each subcontractor or vendor. The Contractor will take such action with respect to any subcontract or purchase order as the contracting agency may direct as a means of enforcing such provisions including sanctions for noncompliance: provided, however, that in the event the Contractor becomes involved in, or is threatened with, litigation with a subcontractor or vendor as a result of such direction by the contracting agency, the Contractor may request the United States to enter into such litigation to protect the interests of the United States.

10.0 INVENTION AND DATA RIGHTS

The following will be applicable to any contract resulting from a selection under this Announcement:

(a) In instances where NASA totally or partially (cost shares) funds an investigation under a NASA contract, NASA is required by law to take title to inventions which may result from the work performed under the contract. The contractor would be granted a royalty free license to practice the invention. The contractor, however, could petition for waiver of such title in accordance with NASA Patent Waiver Regulations 14 C.F.R. 1245.1, whereupon the Agency would give favorable consideration towards waiving title to the invention to the contractor subject to the reservation by the Government of a royalty free license. As a general rule, the contract provides that NASA and the contractor can use and disclose, without restrictions, the data generated under the contract.

(b) In instances where a joint project is undertaken, i.e., the investigator furnishes the experiment without charge to NASA, and NASA accommodates the experiment on a flight without charge (no transfer of funds takes place), NASA will obtain a royalty free license to practice for U.S. Governmental purposes any inventions resulting from the experiment, together with the right to use and disclose the resulting data for U.S. Government purposes.

ATTACHMENT - B

NASA MANAGEMENT PLAN FOR NEW HST SCIENCE INVESTIGATIONS

1.0 INTRODUCTION

This attachment delineates the established HST Program lines of authority and describes corresponding responsibilities of key individuals who will interface with the PI and his/her support team. This attachment also presents a summary of the significant program events beginning with the selection of successful proposals for investigation definition and preliminary design studies and ending with the execution of the scientific investigation. It also outlines the HST management organization that is currently in place. The HST management organization has been specifically designed to meet the needs of a progressively developing flight program and will evolve as necessary.

2.0 PROGRAM PHASES

The National Aeronautics and Space Administration (NASA) Associate Administrator for Space Science and Applications will select the successful proposals from among those received in response to this Announcement of Opportunity. After this selection, the Goddard Space Flight Center (GSFC) will negotiate a contract with each of the successful proposers' institutions. For foreign proposers, a Memorandum of Understanding will be substituted for a contract and will be prepared and negotiated by the International Affairs Division, NASA Headquarters.

Selection will initiate the first of a potentially three-phase program. These three phases are broadly characterized as follows.

- Phase I - Investigation definition and preliminary design study resulting in an updated scientific investigation plan, a preliminary SI design, and a detailed flight development proposal.
- Phase II - Detailed SI design and flight hardware development including launch, testing and operations support
- Phase III - Post launch science investigations.

A summary schedule relating these activities is shown in Figure B-1.

2.1 PHASE IA - Investigation Definition Study

Phase IA will begin following selection. Phase IA will provide a better definition of the investigation including the establishment of

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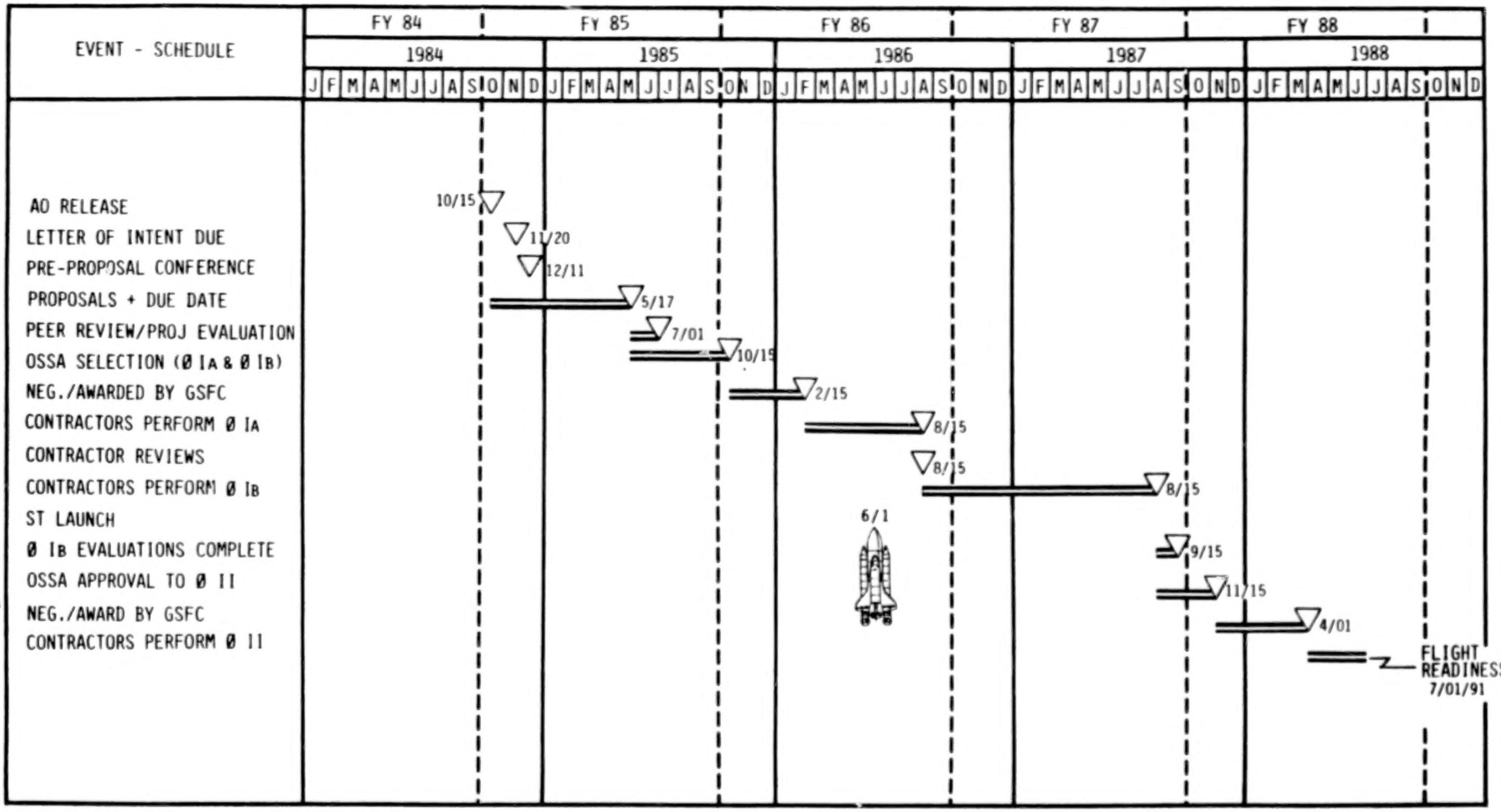
FIGURE B1-SUMMARY SCHEDULE



instrument concepts and requirements to the level required for development of preliminary system design and the assessment of their feasibility. Phase IA will culminate in a Preliminary Requirements Review (PRR) presented to the STP-G.

2.2 PHASE IB - Preliminary Design Study

Phase IB will commence immediately upon completion of Phase IA. During Phase IB, design studies and design specifications will be completed in detail sufficient to proceed with the detailed design and development of the instrument. Complete analyses and breadboarding of critical elements as necessary will be performed and reported to the NASA in support of projected resource requirements and development schedules. During Phase IB, the PI may fine-tune the proposed scientific investigation in terms of a better definition of the capabilities of the scientific instrument. The basic spirit of the originally proposed science investigation must be maintained. The completion of these activities will be scheduled to coincide with the conclusion of the HST in-orbit verification testing of the current SIs. At this time a Preliminary Design Review (PDR) will be presented by each PI to the STP-G. At the completion of Phase IB, each PI will submit a Phase II flight development proposal to NASA. The implementation plan contained within this proposal must include the technical approach, schedules, and resource requirements for the detailed design and the development of the flight instrument and all flight support hardware. Each PI will also be expected to provide a refined scientific investigation plan which should take into account the better definition of instrument capabilities. NASA will then re-evaluate the scientific merit, the technological problems and the costs and risk involved for each of the investigations then under study. Based on this re-evaluation, current in-orbit performance of the existing HST instruments, and resource constraints, the NASA Associate Administrator for Space Science and Applications will for each PI either authorize continued participation or terminate participation.

During Phase I, funding will be provided by the STP-G to support the following specific tasks.

a) Preparation of a science investigation and flight instrument development plan, and a management and cost plan, to be incorporated into the flight development proposal. This proposal will include a refined description of the proposed science investigation and a preliminary SI design that will permit NASA to evaluate the scientific merit, and the technological problems and the costs and risks involved in completing the development of the instrument. This proposal must contain adequate detail to provide an appropriate level of confidence that the PI has reasonable support available and the ability to meet the HST Project milestones. It must contain a Contract End Item Specification for the instrument proposed, plus any exceptions to the applicable interface documents.

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This proposal will incorporate the results obtained during the Phase I activities and will include the technical approach, detailed plans, schedules and resource requirements for Phase II-III. It must also include descriptions of the management structure, personnel qualifications and assignments and costs and schedules to the fourth level of the Work Breakdown Structure (WBS) as described in Attachments C and D.

b) A limited amount of breadboarding of critical subsystems and purchase of long-lead-time components as agreed upon and authorized by the GSFC.

c) Participation in HST Project meetings for which the travel requirements are to be estimated as follows.

   o Working Group Meetings - Regularly scheduled quarterly meetings to be held at the GSFC, Greenbelt, Maryland. Participation by the PI (or occasionally by an appropriate representative) is required.

   o Progress Reviews and Interface Coordination Meetings - Regularly scheduled monthly meetings to be held at the GSFC or MSFC with participation by two members of the PI's support team as appropriate to the subject matter and with up to four members at the final review.

d) Support planning for integration of the SI into the Spacecraft Support Equipment (SSE) for purposes of on-orbit servicing or replacement.

e) Preparation of a plan for storage and maintenance of the SI and GSE, including spares and logistics, during the period between delivery and launch.

f) Preparation of a plan which outlines the method/scheme of implementing fracture control of the hardware during Phase II.

2.3 PHASE II - Detailed Design and Flight Hardware Development

Following authority to proceed with Phase II from the AA/OSSA, the GSFC will provide funding for the detailed design, flight hardware development, and scientific and technical support during the in-orbit checkout period.

Phase II will consist of two parts, a detailed design effort culminating in a Critical Design Review (CDR) and flight hardware development. During the first part of Phase II, the following specific tasks will be funded by the GSFC.

a) Detailed design, analyses and supporting activities necessary to develop the flight instrument and support equipment including the following:

- o Performance analysis and error assessments
- o Complete SI structural mathematical model
- o Complete SI thermal mathematical model.

b) Establishment and implementation of an instrument acceptance program to include:

- o SI acceptance data package
- o SI flight control procedures and software
- o Method of instrument microprocessor and NSSC-1 computer software validation where appropriate.

c) Provision of all necessary support for a CDR.

Following the successful completion of the CDR, the following specific tasks will be funded by the SIP-G.

a) Fracture mechanics analysis of the flight instrument

- o This analysis will support the development of a total fracture control program which includes nondestructive inspection of all fracture-sensitive hardware

b) Development, fabrication, assembly, test and delivery of the following:

- o A flight qualified science instrument
- o A complete ground support system suitable for pre-launch functional testing and post-launch checkout of the instrument.

c) Calibration, functional testing, and checkout of the flight instrument prior to delivery as necessary for acceptance by NASA and at intervals thereafter until launch, as the HST flight schedule may require.

d) Preparation and maintenance of documentation including drawings, procedures and descriptions necessary to control the configuration of the delivered items and to define the preflight and flight interface requirements.

e) Preparation and maintenance of documentation for operations planning, including SI systems description, operations and constraints, procedures and telemetry and command information.

f) Establishment and implementation of reliability, quality control, safety and contamination programs, and preparation of appropriate documentation including a failure mode and effects analysis (FMEA).

g) Preparation of procedures and training of personnel for test, checkout and operation of the ground support equipment.

h) Planning, analysis, and implementation associated with on-orbit integration of the SI into the HST, including the Space Shuttle and associated SSE.

i) Planning and analysis for replacement of subsystem modules and associated astronaut Extra-Vehicular Activity (EVA) requirements.

j) Support, including provision of all necessary personnel, of preflight, launch and science verification activities including the receiving-inspection of the SI, flight integration and SI testing. The PI's team will perform any preflight fault isolation, maintenance and repair of the SI.

k) Support for the development of HST onboard computer software and procedures necessary to enable the Control and Data Handling (SI C&DH) system to support the science instrument.

l) Development of an instrumentation data system approach consistent with the established HST science and engineering data systems policy.

m) Development of computer programs and procedures for processing the science instrument data within the SI or on the ground, whichever is most efficient. This includes providing algorithms and procedures for the reduction and analysis of SI data within the Science Operation Ground System and Science Data Analysis System and supporting the related development of software.

n) Scientific analyses and reporting of data including verification data obtained during the in-orbit checkout period.

o) Participation in HST Project meetings for which the travel requirements are to be estimated as follows.

   - Regularly scheduled quarterly scientific meetings to be held at the GSFC. Participation by the PI (or occasionally by an appropriate representative) is required.

   - Progress Reviews and Interface Coordination Meetings - Regularly scheduled monthly meetings to be held at the GSFC or MSFC with participation by approximately two members of the PI's support team as appropriate to the subject matter.

   - Critical Project Reviews - Total of four meetings at the GSFC or the MSFC scheduled at critical intervals throughout the development phase with adequate participation by members of the PI's support team.

p) Development of updated requirements for Phase III (Science Investigation) support.

q) Provision of all necessary support for a Flight Readiness Review (FRR).

r) Preparation of an updated scientific investigation plan including the identification of specific scientific programs on specific targets.

2.4 PHASE III - Scientific Investigation

The flight qualified instrument delivered by the PI will become a part of the stable of HST science instruments and replaceable units. These instruments and replaceable units will be placed in orbit as part of the HST only as conditions warrant and permit. A schedule for these operations cannot be indicated at this time. However, each PI delivering an HST Science Instrument to NASA will be allotted a minimum on-target HST observing time of 350 hours, and the commencement of the use of this time need not be delayed until after the PI's instrument is placed in orbit. The scientific case for such early observations must be made in the original proposal to this AO (see Section I, page 4). All PIs will have access to all the SIs (subject to constraints of applicable NASA policy), as will all General Observers (GOs) selected from the astronomical community. Thus, a PI may begin to expend up to 15% of his/her allotted observing time (following delivery of the instrument) using any of the then current SIs, providing such use is consistent with the objective of the proposed investigation, and does not conflict with any scientific investigations which have prior approval. The PI will be held fully responsible for attaining the scientific objectives of the original proposal to this AO (in accordance with applicable NASA policy). Six months prior to the launch of a new SI, the PI will deliver his/her final, updated, detailed observing plan to both the ST ScI and the NASA HQ Program Office. Proprietary rights to data delivered to a PI in the conduct of the investigations will continue for one full year following delivery of the data by the ST ScI. Operational scheduling of all HST observations is the responsibility of the ST ScI and NASA will fund the Phase III scientific investigations through the STP-G.

3.0 MANAGEMENT ORGANIZATION

3.1 Program Organization

The HST Program is under the overall direction and authority of the Office of Space Science and Applications (OSSA) at NASA Headquarters. The Associate Administrator of the OSSA is responsible for the Agency-wide planning and direction of the HST program. Within the OSSA, the Associate Administrator has delegated authority for the HST Operations and Maintenance and Refurbishment (M&R) Program management to the Director of the Astrophysics Division. Overall HST science policy is the delegated responsibility of the HST Program Scientist in the OSSA.

3.2 Project Organization

The MSFC has been designated by the NASA Headquarters as the responsible center for the HST Project management including: development of all flight and ground support equipment, launch and in-orbit verification, subsequent operations, and follow-on maintenance and refurbishment. The MSFC Director has established the organization shown in Figure B-2 for carrying out this responsibility and has delegated project authority to the HST Project Manager at the MSFC. Daily scientific oversight of the HST Project is the responsibility of the MSFC HST Project Scientist. The organization of the HST Project will evolve as required once the HST enters its operational phase.

As shown in Figure B-2 as part of the total organization, an HST Project at GSFC (STP-G) has been established. The STP-G is responsible for the HST Science Instruments, including the SI Control and Data Handling (SI C&DH) subsystem onboard the HST, and will be responsible for managing the SI development activities that result from this AO. In addition, the GSFC is responsible for Mission Operations. This responsibility includes the total HST ground operations system, the ST ScI and all other aspects of science operations. The GSFC director has established the organization shown in Figure B-3 for meeting these responsibilities and has delegated project authority to the Deputy Director of Flight Projects for the HST.

The key HST personnel that will regularly interface with the PI and his/her support team are indicated in Figure B-3 and their major responsibilities are described below.

3.3 HST Scientific Instrument Scientist

The Instruments Scientist is currently a member of the STP-G and is responsible for assuring that the performance characteristics of the science instruments remain adequate to meet the HST mission objectives. He/she will be the primary interface between the PI and the STP-G on scientific matters and will ensure that any conflicting SI requirements are resolved in a timely manner. The Instruments Scientist will be aided by other scientists at the GSFC who will work with the PI and his/her staff in a liaison role. The Instruments Scientist's specific duties include the following.

a) Serving as scientific advisor to the STP-G Office

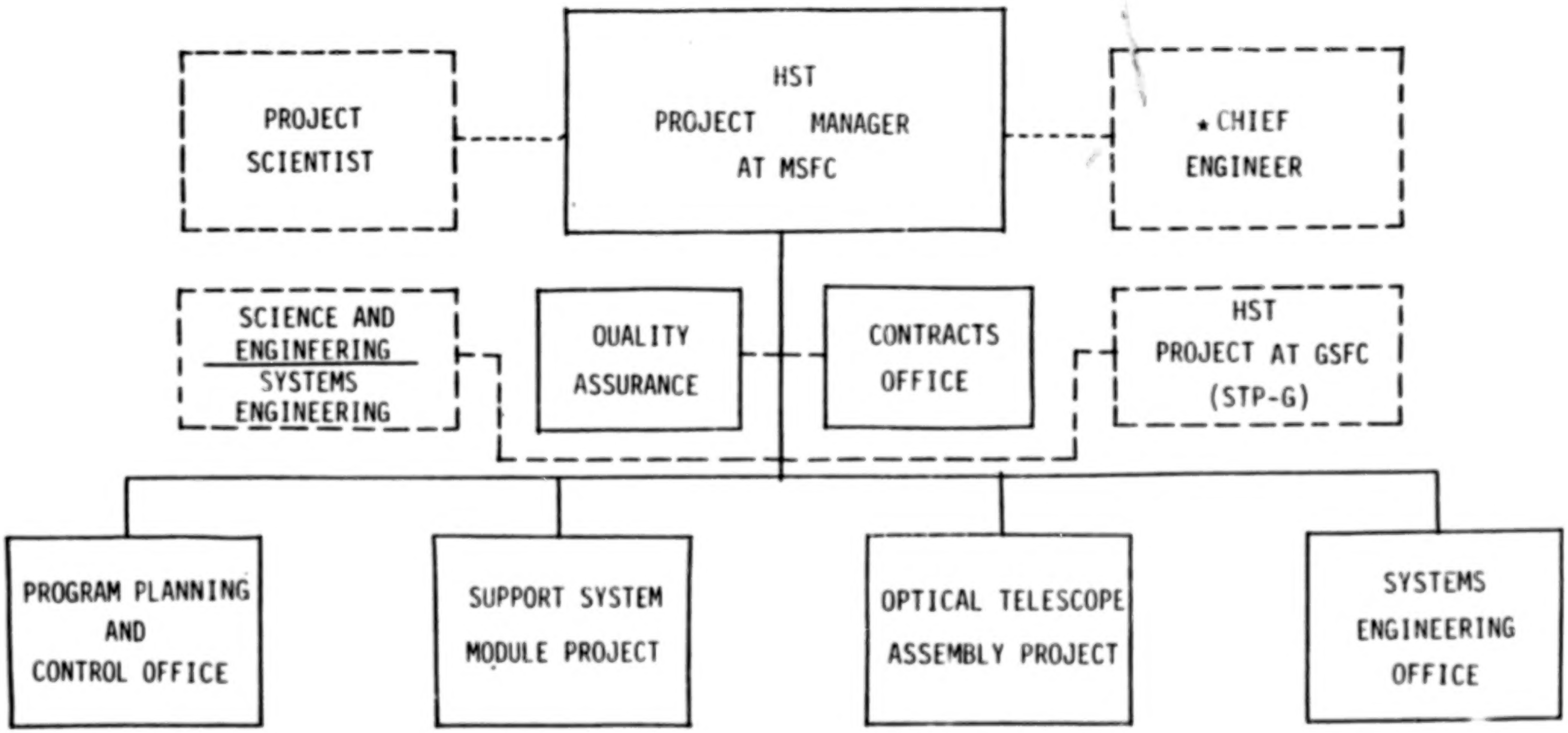
b) Serving as the scientific spokesman on behalf of the PIs and on behalf of the STP-G Office on project affairs

c) Participating in project reviews, meetings and activities to represent the science viewpoint in matters dealing with the SIs

d) Coordinating the preparation of scientific documentation relating to the SIs

e) Participating in negotiations and administration of contracts and Letters of Agreement with the PIs' institutions

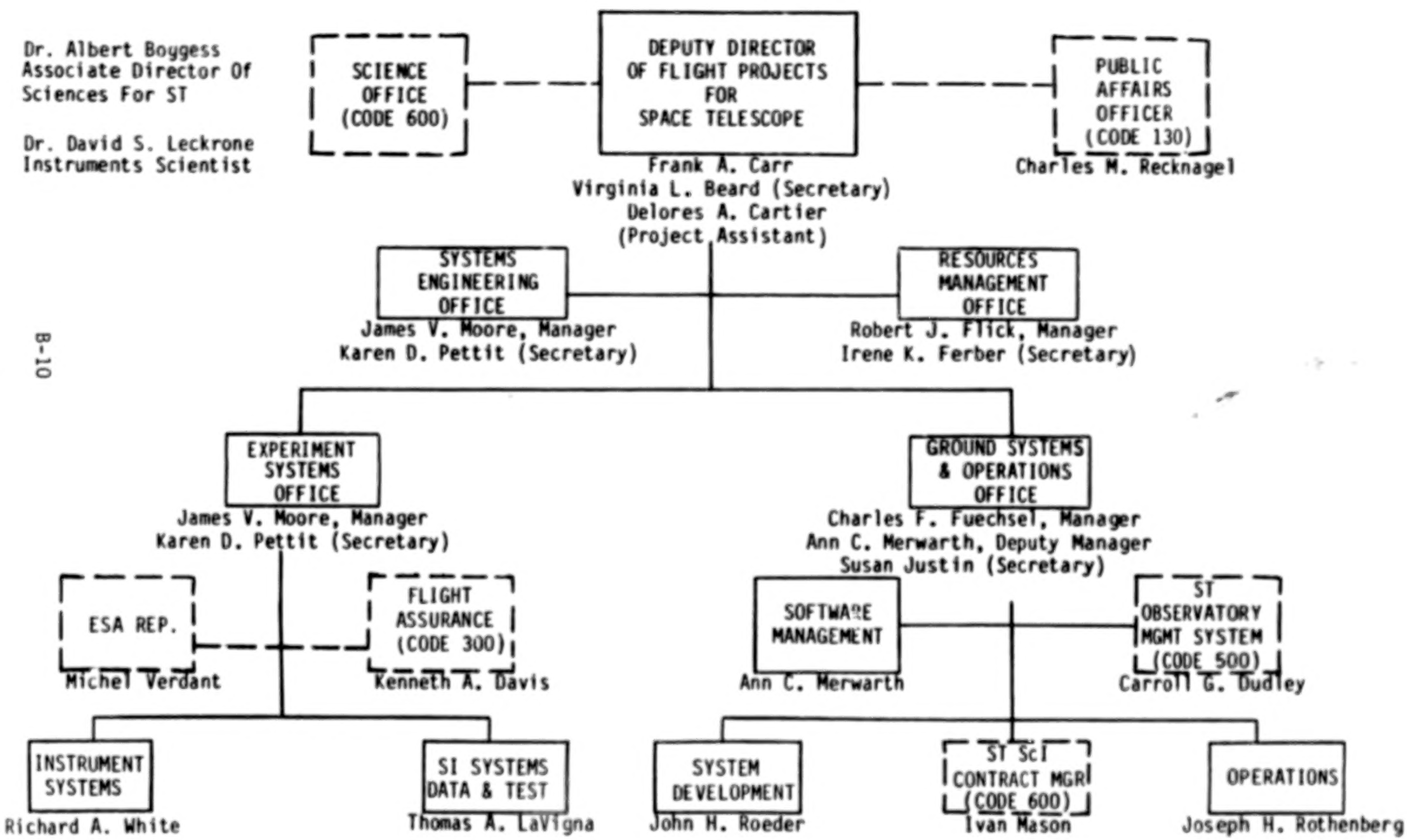
FIGURE B-2 - HST PROJECT OFFICE



*STAFFED BY SCIENCE AND ENGINEERING PERSONNEL

FIGURE B-3. HST PROJECT AT GODDARD

(STP-G/CODE 400.2)



As of June 1, 1984

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f) Coordinating the definition, negotiation and control of the required scientific performance capabilities of the SIs

g) Assisting in establishing interfaces between the PIs and the various elements of the Project to assure effective working relationships

3.4 HST Project Scientist for Operations

The HST Project Scientist for Operations is the member of the STP-G who is responsible for overall scientific operations. He/she will ensure that the PIs receive the required operational support and will work with the Instruments Scientist, the Instrument Systems Manager and the PIs to ensure that any conflicting operations requirements are resolved in an expeditious manner.

The HST Project Scientist for Operations specific duties include the following.

a) Serving as scientific advisor to the STP-G

b) Serving as the science operations spokesman to the PIs and to the STP-G

c) Participating in project reviews, meetings and activities to represent the science viewpoint in matters dealing with scientific operations

d) Coordinating the preparation and documentation of SI scientific operations requirements

e) Advising the STP-G in the definition of the operations/science interface

f) Advising the STP-G in the definition and development of the mission and spacecraft systems design

g) Participating in HST Project reviews and SI meetings to coordinate science operations and to assist the HST Project in mission decisions as they relate to the scientific objectives

3.5 ST ScI Instrument Scientists

During Phase II the ST ScI will formally designate an instrument scientist who will become the primary contact person on behalf of the ST ScI for each of the new PIs. He will provide information to the PI on operational and data management constraints. He will report to the ST ScI the expected performance characteristics, functional and software requirements of the new instrument as they may affect operations, science planning and science data analysis.

3.6 Instrument Systems Manager

The Instrument Systems Manager is the member of the STP-G who will work with the PI's engineering support team on a daily basis. Together, he/she and the PI's team will develop schedules and budgets consistent with current HST Project schedules, and fiscal constraints and systems engineering guidelines. Implementation of any changes that are approved by and within the authority of the HST Project is the responsibility of the Instrument Systems Manager. Changes that are significant (and in particular, those that may affect the scientific performance of the instrument) will require the approval of the NASA Associate Administrator for Space Science and Applications.

The specific duties of the Instrument System Manager include the following

a) Providing technical support and analyses to the NASA Headquarters HST Program Office, the HST Science Working Group and the PIs and their teams

b) Managing preparation of the Contract (or Letter of Agreement) for Phases I and II

c) Monitoring the technical progress of the PIs and their teams

d) Developing and implementing the SI development and management plan

e) Reviewing and obtaining approval of equipment requirements, designs, interface specifications and testing plans

f) Monitoring adherence to documentation and configuration management requirements

g) Monitoring and coordinating development, testing and delivery schedules

h) Monitoring adherence to reliability, quality assurance and practice and procedures standards

i) Providing technical data, spacecraft designs and specifications, parts and processes data to the PIs and their teams

j) Scheduling and coordinating test activities including the use of government facilities as needed

k) Maintaining continuous liaison with PIs, contractors, subcontractors and suppliers regarding costs, status, schedules and test results

l) Scheduling and conducting formal reviews

m) Coordinating the preparation and documentation of overall HST scientific operations and data requirements

n) Providing direction in the planning and implementation of scientific operations and data processing

o) Assisting in the definition, negotiation and control of the technical interfaces and assuring effective working relationships among responsible parties.

4.0 SCIENTIFIC INVESTIGATION DEFINITION TEAM

The scientific investigation definition team that will be established as a result of negotiations between the GSFC and the PI's institution will include an Experiment Manager in addition to the PI. This team will be structured according to the following guidelines.

4.1 Principal Investigator

The PI has full responsibility and fiscal accountability for all activities related to the science investigations funded by NASA. This includes the development of all necessary equipment; the delivery of this equipment as scheduled and within budget limitations; the final performance of all equipment; and the quality of the scientific investigations and the reporting of science results. The PI must be supported by a scientific and engineering support team. This team may include co-investigators who have clearly defined responsibilities involving development of the science instrument and/or definition and conduct of the scientific investigations. The PI must be supported by an Experiment Manager to assist him in developing and maintaining an implementation plan that includes task definitions, task assignments, milestone schedules and resource allocations. The PI is responsible for generating all required documentation including reports and any necessary presenations. The PI is responsible for the design, fabrication, testing and calibration of all equipment and for validating their adequacy in meeting the overall requirements. In addition, the PI has the following specific duties.

a) Participating in project reviews and science coordination meetings

b) Directing the preparation of all plans and endorsing all reports and documentation (including all revisions thereto) relating to his/her responsibilities

c) Participating in STP-G mission planning and providing support relating to his/her instrument as needed

4.2 Experiment Manager

The Experiment Manager is responsible to the PI for the design, development, fabrication and testing of the science instrument and of the

ground support instrumentation, including associated bench-test equipment and software. The Experiment Manager is the primary point of contact between the scientific investigation development team and the STP-G on engineering matters. Specifically, he will perform the following functions.

a) Negotiate interface specifications with the STP-G

b) Provide cost and schedule data, monthly technical and financial reports and support of Project reviews as required

c) Prepare all the engineering documentation including management plans, instrument descriptions, specifications, fabrication drawings, test plans and reports

d) Manage the design, development, fabrication, calibration, test, checkout and launch support activities

e) Manage unit-level and system-level qualification and acceptance testing of all equipment

f) Manage the engineering support activities of the Scientific Investigation Development Team during system integration and testing, prelaunch, launch and flight operations

ATTACHMENT C

GUIDELINES FOR PREPARING THE INVESTIGATION AND TECHNICAL PROPOSAL

1.0 INTRODUCTION

These guidelines delineate the minimum amount of technical information that must be addressed in the proposals. While it is recognized by NASA that the level of detailed information requested may not be explicitly available for inclusion in the proposal, every attempt should be made to either:

a. Include the level of definition as requested, or

b. Provide a discussion which will clearly indicate to NASA that the requirement is understood and will be provided during Phase I.

If the latter option is selected, the bidder should provide a plan which clearly demonstrates how he ultimately will define and provide the requested information at the conclusion of the Phase I effort.

It must be assumed by each proposer that the extent of explicit information provided in each area defined below will improve the competitive posture of the proposal. Item three of the outline below should be addressed to knowledgeable astronomers. It should give a clear presentation of the proposed investigation, including the basic instrumental features, but it should not repeat extensive details contained in other sections.

Information provided under Items 4 through 22 should adequately demonstrate the feasibility of the proposed SI design. If necessary technology does not already exist, the plan must establish how it can be developed to meet the instrument performance goals in a timely fashion. Finally, the PI should describe the requirements his/her investigation would place on the operation of the HST observatory and on ground-based processing. Any deviation from the constraints specified in the AO, its attachments, or reference should be described and justified in detail with reasons for the proposed changes.

2.0 INVESTIGATION AND TECHNICAL PROPOSAL OUTLINE

1. Experiment Title

2. Experiment Personnel

   2.1 Scientific Investigators: name, institution, address, phone number (office/home), specific areas of responsibility

   2.2 Other Key Personnel: information as above

3. Scientific Investigation

3.1 Science objectives to be accomplished

3.2 Importance of science objectives

3.3 Science data to be collected

3.4 Unique advantages of ST to the proposed scientific investigation

3.5 Method of performing data analysis in a timely manner

3.6 Overview of instrument design as related to meeting scientific objectives

3.7 Unique features of instrumentation for this scientific investigation

3.8 Technical status of the instrument and its key components

3.9 Discussion of problem areas

3.10 Scientific Investigators' roles in this investigation and related background

4. Scientific Investigation Parameters

4.1 Spectral range

4.2 Spectral resolution

4.3 Field of view

4.4 Spatial resolution

4.5 Temporal resolution

4.6 Photometric characteristics

5. SI Description and Principal of Operation

5.1 Operating modes and relation to scientific objectives

5.2 Functional block diagrams

5.3 Descriptions and schematics

5.3.1 Optics

5.3.2 Detectors

5.3.3 Electronics

5.3.4 Mechanisms

5.3.5 Thermal

5.3.6 Power Supply

5.3.7 Structural

6. Attitude Requirements

6.1 Pointing accuracy/precision

6.2 Pointing stability

6.3 Aspect determination

6.4 Roll requirements

6.5 Slew/tracking requirements

6.6 Raster requirements

6.7 Target acquisition requirements (modes)

7. SI Operation

7.1 Calibration

7.1.1 Radiometric

7.1.2 Geometric

7.1.3 Wavelength

7.1.4 Alignment

7.2 Duty cycle

7.3 Event-related operation

7.4 Length of observation (exposure times and rates)

7.5 Real-time operation requirements

8. Quick-look Data Requirements

8.1 Amount of data

8.2 Frequency of output

8.3 Format

8.4 Processing required

9. Science Ground Data Processing Requirements

9.1 Requirements for production data processing

9.1.1 Hardware/software

9.1.2 Data rate (e.g., bits/day)

9.2 Output products

9.2.1 Type (e.g., tape, hardcopy, etc.)

9.2.2 Format

9.3 Data analysis plans

10. Mechanical Interface

10.1 Envelope dimensions (outline drawing)

10.2 Field of view requirements

10.3 Exposed materials

10.4 Weight (including detector subsystem, electronics subsystem, structure, mechanics, optics, thermal control, and wiring harness)

10.5 Center of gravity

10.6 Alignment requirements

10.7 Materials (outgassing sources, magnetic materials, surface coatings)

10.8 Mounting arrangement (compatibility with ICD)

10.9 Co-alignment requirements with other instruments

10.10 Inertias (3 orthogonal axes)

10.11 Location of connectors

10.12 Covers

10.13 Aperture alignment stability

10.14 Venting and purging

10.15 On-orbit replaceable subsystem interfaces and access provisions

10.16 Structural analysis data

11. Electrical Interface

11.1 Power

11.1.1 Power consuming modes

11.1.2 Power vs time profile on a per-orbit basis for each mode

11.1.3 Transients

11.1.4 Converter operating frequencies

11.1.5 Special requirements

11.2 Spacecraft signals required

11.2.1 Clock (accuracy)

11.2.2 Other

11.3 Connector size, type and number of pins (interface, test)

12. Control

    12.1 Discrete stored commands and rates

    12.2 Serial stored commands and rates

    12.3 On-board command storage requirements (bits)

    12.4 Discrete real-time commands and rates

    12.5 Serial real-time command rate

    12.6 On-board SI C&DH software requirements

        12.6.1 Type (data processing, SI sequences, etc.)

        12.6.2 Storage (no. of bits)

    12.7 On-board closed loop control processing requirements

    12.8 Command routing

13. Telemetry Data (Engineering and Science)

    13.1 Quantity and type of data

        13.1.1 Analog (number of signals/functions)

        13.1.2 Single bit digital (number of signals/functions)

        13.1.3 Serial digital (number of distinct measurements)

    13.2 Data sampling rates

    13.3 On-board data storage requirements (science and engineering)

    13.4 On-board engineering data processing requirements

    13.5 Special on-board data processing requirements

    13.6 Data routing

14. Thermal Characteristics

    14.1 Operating temperature limits (compatibility with ICD)

    14.2 Non-operating temperature limits (compatibility with ICD)

    14.3 Transportation and storage temperature limits

    14.4 Gradients, hot spots, cold spots

    14.5 Surface characteristics

    14.6 Temperature sensors (telemetry readout)

    14.7 Cold plate requirements

    14.8 Power profiles

    14.9 Thermal analysis data

15. Pneumatics
    15.1 Purpose
    15.2 System description
    15.3 Type of gas
    15.4 Volume
    15.5 Pressure (psi)

16. Cryogenics
    16.1 Purpose
    16.2 System description
    16.3 Type of coolant
    16.4 Volume
    16.5 Pressure (psi)

17. Radioactive Sources
    17.1 Type and number
    17.2 Location
    17.3 Strength
    17.4 Purpose (in-flight, test)

18. Environmental Monitoring Requirements; on Ground and in Orbit
    18.1 Particulate and molecular contamination limits
    18.2 Moisture
    18.3 Industrial gas vapors
    18.4 Temperature limits
    18.5 Static charge
    18.6 Surface residues and materials
    18.7 Radiation monitor
    18.8 Pressure gauge

19. Precautions (Ground and Orbital)
    19.1 Storage
    19.2 Handling
    19.3 Operating constraints and interdependencies
    19.4 Transportation shock and vibration

20. Interference

20.1 Internally generated

20.1.1 Electrical

20.1.2 Magnetic

20.1.3 Radioactive

20.1.4 Outgassing

20.1.5 Mechanical

20.2 Susceptibility

20.2.1 Electrical

20.2.2 Magnetic

20.2.3 Radioactive

20.2.4 Outgassing

20.2.5 Mechanical

20.3 Grounding Provisions

21. Instrument and Higher Assembly Level Tests

21.1 Tests at experimenter's and other facilities

21.2 Qualification and acceptance program support

21.3 SI integration support

21.4 SI launch operations support

21.5 SI in-orbit checkout tests

22. Reliability and Quality Assurance

22.1 Failure Mode and Effects Analysis (FMEA)

22.2 Critical Items List (CIL)

22.3 Hazard analysis

22.4 Strength and fracture mechanics

23 Unique Ground Support Equipment

23.1 Test equipment (amount and type)

23.1.1 In-plant facility

23.1.2 Qualification and acceptance program

23.1.3 SI integration

23.1.4 Operations

23.2 Instrument handling equipment (amount and type)

- 23.2.1 In-plant facility
- 23.2.2 Qualification and acceptance program
- 23.2.3 SI integration
- 23.2.4 On-orbit servicing

GUIDELINES AND INFORMATION FOR PREPARING THE MANAGEMENT/COST PROPOSALS

1.0 INTRODUCTION

The information requested in this attachment must be submitted in detail for Phase I. In addition, best estimates must be provided in this proposal for the subsequent phases. It must be assumed by each proposer that the extent of explicit information provided in each area defined below will improve the competitive posture of the proposal.

The Management/Cost Proposals must provide detailed plans for: a) organizing the investigation technical team, b) organizing the institution's science and engineering support, c) utilizing major subcontractors, d) meeting major controlled milestones, and e) controlling cost.

2.0 MANAGEMENT PROPOSAL

2.1 Contracting Approach

The Management Proposal should present the PI's management approach for developing his/her investigation from the period of selection through SI in-orbit checkout and scientific operations (Phases I, II, and III). In this part of his/her proposal, the PI should concentrate on a feasible approach and schedule for contracting with his/her team members and major industrial subcontractors.

The Management Proposal must clearly describe the PI's subcontractor selection and contracting process (including all major assumptions) in sufficient detail to convince the NASA selection official that the PI can complete the investigation, control cost, and maintain schedules. The Management Proposal must also clearly present and justify the PI's make-or-buy decisions.

2.2 PI's Organization Structure

The PI shall provide a description of the proposed organization that will be responsible for the development of the SI. The PI should also describe the relationships between the scientific and engineering teams, subcontractors, and the GSFC. Internal lines of authority, responsibility, and interfaces should be addressed specifically. A description of the relationship of key personnel to the Work Breakdown Structure should also be provided.

The PI shall describe the qualifications and responsibilities of key members of the team. The PI should also provide information on the qualifications, related experience, and commitment of the key engineering and management personnel assigned by the sponsoring institution. In the case that

subcontractors have been selected, this same information should be provided including justification for this selection.

2.3 Contract Work Breakdown Structure

Figure D-1 of this attachment is a Work Breakdown Structure (WBS) that should be used in preparing the cost plan for domestic proposals. This WBS will provide a common baseline for the comparison of competing proposals and assist the proposer in developing his/her cost/management techniques.

2.4 Schedule

The PI shall provide schedules as required for the complete development and execution of his/her scientific investigation (Phase I, Phase II, and Phase III). Schedules must be provided in sufficient detail to ensure that the PI can meet the specified ST Project milestones and delivery dates for hardware, software, and documentation. Preliminary work flow charts as described in Section 4.4 should also be provided with this proposal.

3.0 COST PROPOSAL (U.S. INVESTIGATORS ONLY)

The PI must provide the total cost plans for his/her participation in the ST Project during Phase I, Phase II, and Phase III. All assumptions must be clearly stated and reasons described. In addition, the cost plan must describe what plan of action the PI will follow to ensure that his/her instrument will be developed under a controlled, minimum cost approach.

This cost plan should present NASA with all costs associated with Phase I/Phase II/Phase III participation. The cost estimate must be reported in current year dollars by element of cost by WBS, by government fiscal year for each of the three phases. Figures D-2, D-3, D-4, and D-5 provide formats for supplying this information.

4.0 INFORMATION ON DOCUMENTATION, MEETING, AND REVIEW REQUIREMENTS

The following information is provided to assure that each investigation team is aware of the scope of required documentation, meetings, and reviews.

4.1 General

Table D-1, Deliverable Documents, is a listing of documents required by the Science Instrument (SI) Office. The SI Office reserves the option of reviewing any additional documentation available at the PI's or his/her contractor's facility.

4.2 Progress Reporting

Each PI shall submit a monthly technical report in letter form to the SI Office (Table D-1, item 1). These reports are to be brief and factual,

highlighting the following areas: overall status with respect to the schedule; a listing of current or anticipated problems with potential impacts and solutions. Monthly and quarterly financial reports (Table D-1, item 2) shall be submitted as detailed in NHB 9501.2A, Procedures for Contractor Reporting of Correlated Cost and Performance Data.

4.3 Configuration Control Reporting

All changes during Phase II affecting the performance or physical characteristics of the instrument, ST interfaces, scientific goals, cost and/or delivery schedule must be brought to the immediate attention of the GSFC SI Manager. A preliminary configuration management plan (Table D-1, item 6) will be delivered during the Phase I study.

4.4 Work Flow Charts

Each PI shall develop time-related work flow charts showing major design, fabrication, assembly, inspection, and test operations to be accomplished. Individual flow charts shall be provided for the optical, mechanical, thermal, electrical, and detector subsystems. Using the above information, an overall system work flow chart shall be provided showing subsystem integration into the SI package and SI qualification and acceptance testing.

4.5 Meetings and Reviews

NASA requirements for project meetings and reviews are outlined in the SI Management Plan (Attachment B). The PI should justify the need for and specify any additional meetings or reviews he/she plans to conduct during the course of the SI design and development.

Figure D-1 Work Breakdown Structure for Cost Proposal

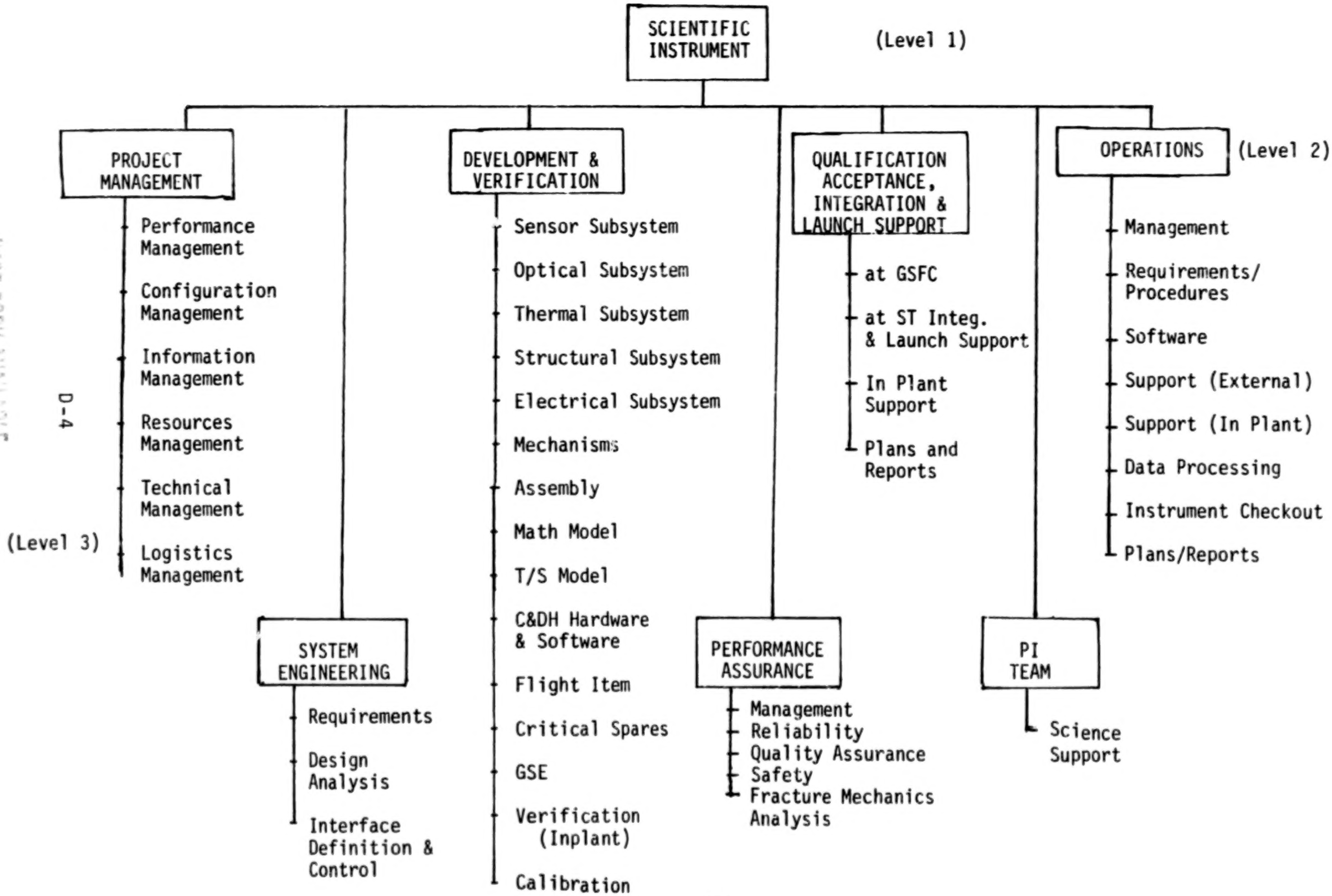

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FIGURE D-2a

SPACE TELESCOPE CONSOLIDATION SUMMARY MANHOURS

	Phase I	Phase II	Total
PROJECT MANAGEMENT			
Prime			
Sub			
Total Project Mgmt.			
SYSTEM ENGINEERING			
Prime			
Sub			
Total System Eng.			
PERFORMANCE ASSURANCE			
Prime			
Sub			
Total Performance Assurance			
DEVELOPMENT & VERIFICATION			
Prime			
Sub			
Total Development & Verification			
QAP, ST INTEG. & LAUNCH SUPPORT			
Prime			
Sub			
Total Support			

FIGURE D-2a (cont'd)

SPACE TELESCOPE CONSOLIDATED SUMMARY MANHOURS

	Phase I	Phase II	Phase III	Total
PI TEAM				
Prime	______	______	______	______
Sub	______	______	______	______
Total PI Team Support	______	______	______	______
OPERATIONS				
Prime	______	______	______	______
Sub	______	______	______	______
Total Operations	______	______	______	______
TOTAL INSTRUMENT				
Prime	______	______	______	______
Sub	______	______	______	______
Total	______	______	______	______

Note:

- o Each major heading is taken from Level 2 of the WBS in Figure D-1.
- o List each major subcontract as a separate line item.
- o Back-up information must be available to 3rd level in WBS shown in Figure D-1.

FIGURE D-2b

SPACE TELESCOPE CONSOLIDATION SUMMARY TOTAL COST

	Phase I	Phase II	Total
PROJECT MANAGEMENT			
Prime	______	______	______
Sub	______	______	______
Total Project Mgmt.	______	______	______
SYSTEM ENGINEERING			
Prime	______	______	______
Sub	______	______	______
Total System Eng.	______	______	______
PERFORMANCE ASSURANCE			
Prime	______	______	______
Sub	______	______	______
Total Performance Assurance	______	______	______
DEVELOPMENT & VERIFICATION			
Prime	______	______	______
Sub	______	______	______
Total Development & Verification	______	______	______
QAP, ST INTEG. & LAUNCH SUPPORT			
Prime	______	______	______
Sub	______	______	______
Total Support	______	______	______

FIGURE D-2b (cont'd)

SPACE TELESCOPE CONSOLIDATED SUMMARY TOTAL COST

	Phase I	Phase II	Phase III	Total
PI TEAM				
Prime	____	____	____	____
Sub	____	____	____	____
Total PI Team Support	____	____	____	____
OPERATIONS				
Prime	____	____	____	____
Sub	____	____	____	____
Total Operations	____	____	____	____
TOTAL INSTRUMENT				
Prime	____	____	____	____
Sub	____	____	____	____
Total	____	____	____	____

Note:

- o Each major heading is taken from Level 2 of the WBS in Figure D-1.
- o List each major subcontract as a separate line item.
- o Back-up information must be available to 3rd level in WBS shown in Figure D-1.

FIGURE D-3

SCIENTIFIC INSTRUMENT SUMMARY

	Man Hours Total	Total Cost
PROJECT MANAGEMENT		
SYSTEMS ENGINEERING		
PERFORMANCE ASSURANCE		
DEVELOPMENT AND VERIFICATION		
QAP, ST INTEG. & LAUNCH SUPPORT		
PI TEAM SUPPORT		
OPERATIONS		
TOTAL		

Note:

This summary of the total cost and manpower is a consolidation of the results presented in the previous two charts.

FIGURE D-4

SPACE TELESCOPE SI TIME PHASED COST

PHASE I	
1986	
January - March	____________
April - June	____________
July - September	____________
October - December	____________
1987	
January - March	____________
April - June	____________
July - September	____________
Total Phase I	____________
PHASE II	
1987	
October - December	____________
1988	
January - March	____________
April - June	____________
July - September	____________
October - December	____________

FIGURE D-4 (cont'd)

PHASE II (cont'd)

<u>1989</u>

January - March	____________________
April - June	____________________
July - September	____________________
October - December	____________________

<u>1990</u>

January - March	____________________
April - June	____________________
July - September	____________________
October - December	____________________

<u>1991</u>

January - March	____________________

o Continue with quarterly breakdown through completion of in-orbit check-out assuming no gap in development schedule.

Note:

o This cost breakdown is for Level 1 of the WBS in Figure D-1.

FIGURE D-5 - SPACE TELESCOPE CONSOLIDATED SUMMARY TOTAL COST

	Phase I	Phase II	Phase III	Total
Direct Labor				
Overhead				
Materials				
Subcontractor				
Special Equipment				
Travel				
Other Costs				
G&A				
Fee (if applicable)				

Attachments to this schedule should be submitted which provide all backup data as specified in part VIII, Proposal Preparation Information, C., Cost Proposal.

TABLE D-1

DELIVERABLE DOCUMENTATION AND SOFTWARE

Item No.	Item Name
1	Monthly Technical Progress Reports
2	Monthly/Quarterly Financial Reports
3	Scientific Investigation Technical Plan and Management/Cost Plan for Phase II
4	Preliminary Design Specification
5	Phase II Final Reports
6	Configuration Management Plan
7	CEI Specification, Part II
8	Work Flow Charts per WBS
9	Performance Verification Plan
10	Verification Procedures and Reports
11	SI Calibration Plan
12	SI Pre-launch Calibration Report
13	SI System Orbital Scientific Performance Assessment and Calibration Report
14	GSE Description
15	Customer Review Data Package
16	Acceptance Data Package and Test Reports
17	Interface Data Inputs for ICDs
18	SI Command and Data Lists
19	Instrumentation Program and Component List
20	Documentation, SI Ground Data Management and Analysis Software
21	Documentation, SI Ground Test Software
22	Documentation, SI Flight Software

TABLE D-1 (cont'd)

Item No.	Item Name
23	Logistics Plan
24	SI Operations and Data Management Plan
25	SI Operations and Data Management Procedures
26	SI Science and Mission Operations Scheduling and Planning Inputs
27	Performance Assurance Plan(s)
28	Safety Compliance Data Package
29	Scientific Investigation Studies Report
30	SI Systems Description and Users' Handbook
31	Mass Properties Report
32	SI Mathematical Models and Analyses
33	Fracture Mechanics Plan and Analysis
34	Drawing Documentation
35	Major Non-Conformance and Functional Failure Reports
36	Worst Case Analysis/Parts Stress Analysis/FMEA
37	SI Handling Procedures and Constraints
38	Instrument Log Book
39	Contamination Control Plan
40	Electrical Schematics and Wiring Diagrams
41	Mass Properties Report
42	Materials Utilization List
43	SI Development Flow Diagram (PERT Network)
44	Preliminary Requirements Review Data Package
45	Preliminary Design Review Data Package
46	Critical Design Review Data Package
47	Pre-shipment Review (Flight Readiness Review) Data Package

ATTACHMENT E

PROJECTED SPACE TELESCOPE IMAGE QUALITY

1.0 INTRODUCTION

The final design for the Space Telescope has produced a narrow range for the principal parameters affecting image quality. Much of the fabrication, assembly, and verification is yet to be performed, however, and some deviation from the current predictions is anticipated. As an aid to prospective proposers, this section will outline the image quality that is anticipated, based on the current OTA and SSM status. Two points should be made regarding the data contained in this document: (1) Although two levels of ST image quality are discussed, only the minimum acceptable ST performance specification is assured by NASA; and (2) The performance predictions in terms of point spread function (PSF) and encircled energy function (EEF) were generated by NASA for information only and are not included as contractual requirements for optical performance specifications.

2.0 THEORETICAL IMAGE QUALITY OF THE OPTICAL DESIGN

The Space Telescope optical design, an aplanatic Cassegrain, is summarized in Table E-1. Only minor deviations from this basic prescription are anticipated. The design is virtually free of all aberrations through third order, except for astigmatism and field curvature. Figure E-1 illustrates the curved astigmatic field. For a perfect optical system of this design, the monochromatic, axial PSF would be as shown in Figure E-2 at a wavelength of 632.8 nm. The EEF, the integral of the PSF, is shown in Figure E-2, as well.

Figure E-2 implies rotationally symmetric images on-axis. Off-axis images would show the asymmetric pattern characteristic of astigmatism, although for field angles less than two arc-minutes the PSF would not be significantly different from Table E-1 at the best compromise focus.

3.0 OPTIMISTIC ESTIMATE OF IMAGE QUALITY

The Space Telescope performance goal is to approach the diffraction-limited performance indicated in Figure E-2. Accordingly, a total wavefront error (ω) goal of 0.05 wavelength RMS (measured at 632.8 nm) has been established as a design goal for the OTA. The wavefront error budget that results in a system wavefront error of 0.05 wavelength RMS is built up from stringent tolerances on virtually every subsystem of the OTA. This includes the total wavefront error in the exit pupil of the telescope as well as a reasonable allowance for misalignment of SIs from the ideal focal surface, even after replacement on orbit. The wavefront error budget accounts for static misalignment of the optical components and dynamic drifts throughout 24 hours of observation. Each subsystem of the OTA and OTA/SI interface is designed in compliance with the 0.05 wavelength RMS wavefront error budget.

TABLE E-1

OPTICAL SYSTEM CHARACTERISTICS

Aperture	2.4 m
Focal Ratio	f/24
Total Obscuration (Area)	13.89 percent
Effective Focal Length (EFL)	57.61179462 m
Back Focal Length (BFL)	1.5 m
Relative Back Focal Length	6.4 m
Plate Scale	0.017357557 mrad/mm
Field of View Diameter	8.1 mrad (28 arc-min) (467 nm)
Data Field Diameter	5.2 mrad (18 arc-min) (300 nm)
Tracking Field Size	1.5×10^{-5} sr (180 arc-min)^2
Wavelength Range	100 nm to 1 mm
Secondary Mirror Aperture	0.31 m
Secondary Mirror Magnification	10.4

The predicted axial monochromatic PSF at 632.8 nm for a Space Telescope of this quality is shown in Figure E-3. This PSF represents the instantaneous image profile, assumed rotationally symmetric, and does not include any smearing due to image motion caused by pointing instability or vibrations. The image motion design goal is not to exceed 0.007 arc-second RMS (1σ) (approximately one-tenth of the Rayleigh resolution of the perfect telescope). The degradation to image quality from this degree of image motion will vary with exposure and the form of the image motion. Assuming that the image motion is a Gaussian random motion with standard deviation of 0.007 arc-second and that the exposure is long compared to the bandwidth of the instability, the axial PSF at 632.8 nm would be as shown in Figure E-4. The only noticeable effect is a slight smoothing of the contrast of the dark rings but no appreciable influence on the EEF. In general, the degradation due to this level of image motion for the Space Telescope is slight compared to the wavefront error degradation.

Figures E-5 and E-6 show the predicted monochromatic PSF and EEF on-axis at 325 nm with and without image motion, respectively. Figures E-7 and E-8 show the same information at 121.5 nm. Note that the wavefront error parameter has not changed for the latter four curves (ω = 0.05 wavelength as measured at 632.8 nm). Of course, if the wavefront error were measured at the shorter wavelengths, it would be proportionally larger.

4.0 MINIMUM ACCEPTABLE LEVEL OF IMAGE QUALITY

A minimum scientifically acceptable performance specification has been established in terms of encircled energy of 70 percent at 0.1 arc-second radius. In terms of wavefront error, the minimum acceptable level of performance translates to 0.075 wavelength RMS as measured at 632.8 nm and represents a guaranteed minimum ST optical performance specification. (Note that this level of performance still represents a near diffraction-limited system according to Marechal's criterion.) For image motion, the minimum acceptable level of performance has been defined as 0.012 arc-second RMS (1σ).

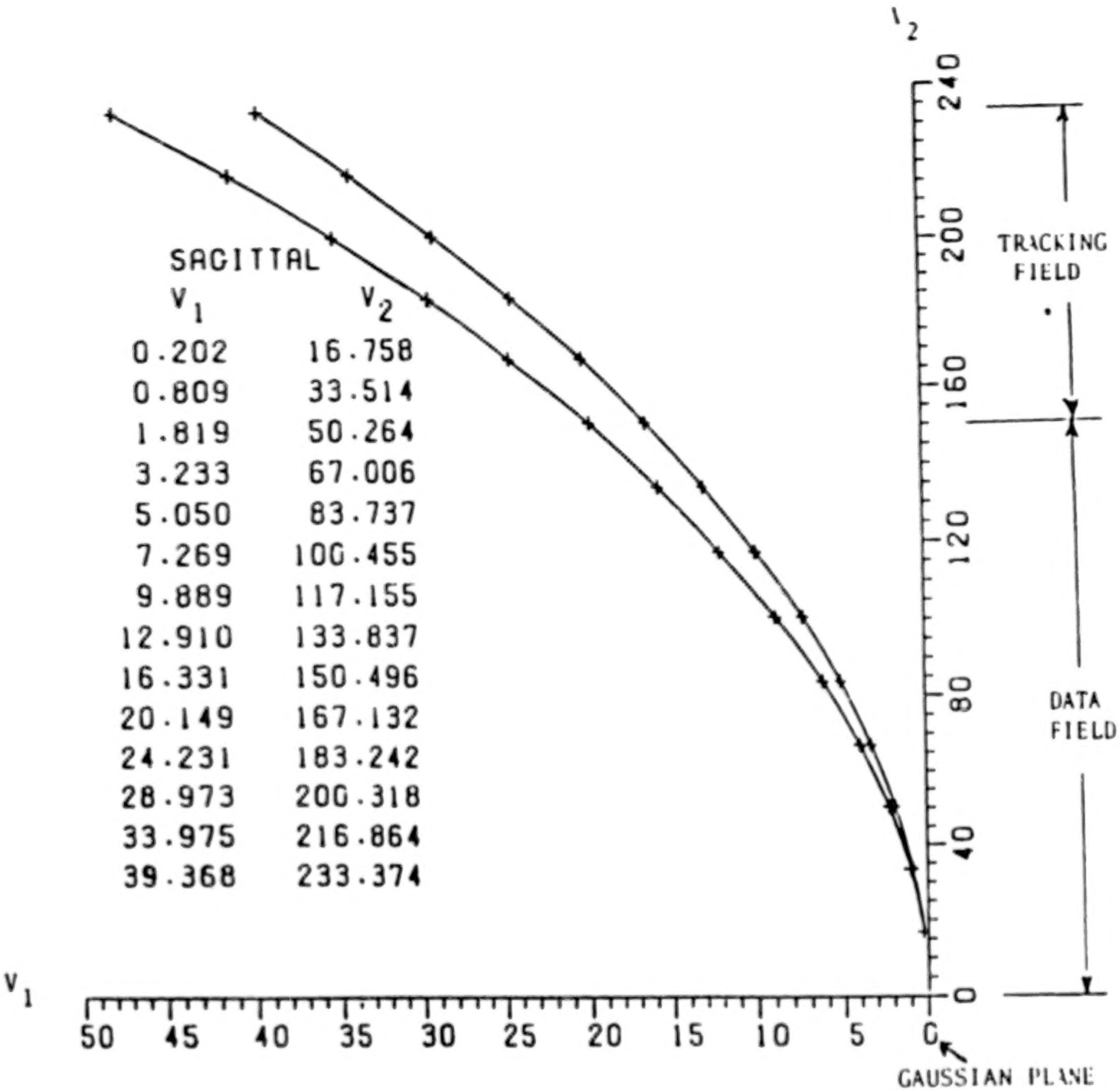
Predictions of axial PSF and EEF curves corresponding to the 0.075 wavelength system are given in Figures E-9, E-10, and E-11 for wavelengths of 632.8 nm, 250 nm, and 121.5 nm, respectively, with no image motion. Figures E-12, E-13, and E-14 show the same functions with 0.012 arc-second of image motion.

FIGURE E-1

ST MEASURED RADII DESIGN

ASTIGMATIC FOCI

FIELD (min.)	TANGENTIAL V_1	TANGENTIAL V_2	SAGITTAL V_1	SAGITTAL V_2
1.00	0.244	16.758	0.202	16.758
2.00	0.976	33.513	0.809	33.514
3.00	2.195	50.262	1.819	50.264
4.00	3.902	67.000	3.233	67.006
5.00	6.095	83.725	5.050	83.737
6.00	8.775	100.433	7.269	100.455
7.00	11.939	117.121	9.889	117.155
8.00	15.588	133.786	12.910	133.837
9.00	19.719	150.423	16.331	150.496
10.00	24.332	167.032	20.149	167.132
10.97	29.265	183.110	24.231	183.242
12.00	34.995	200.145	28.973	200.318
13.00	41.043	216.644	33.975	216.864
14.00	47.565	233.100	39.368	233.374



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06/17/82

ST Diffraction Limited Performance
33 Per Cent Central Obscuration (diameter)
Wavelength = 0.6328 microns

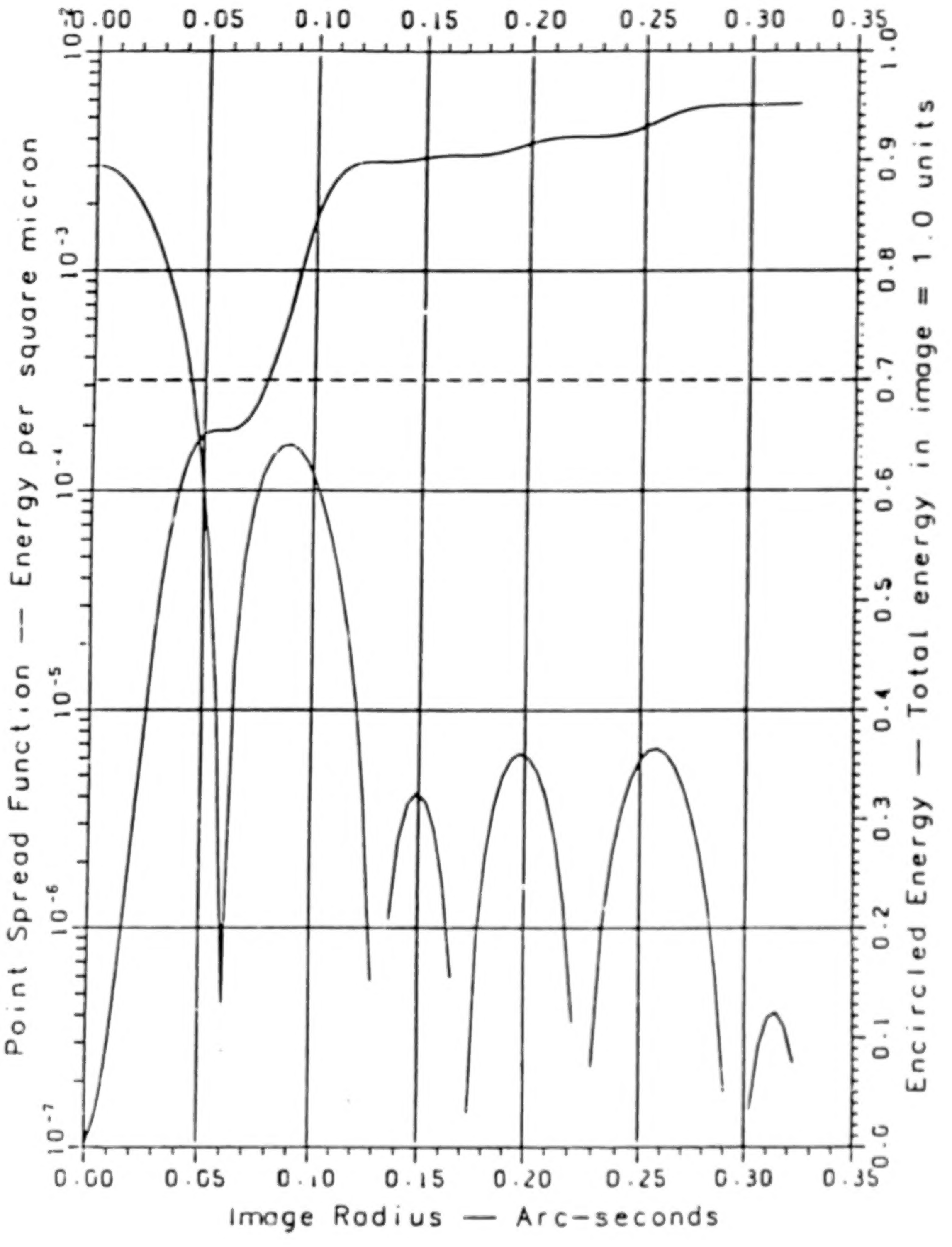
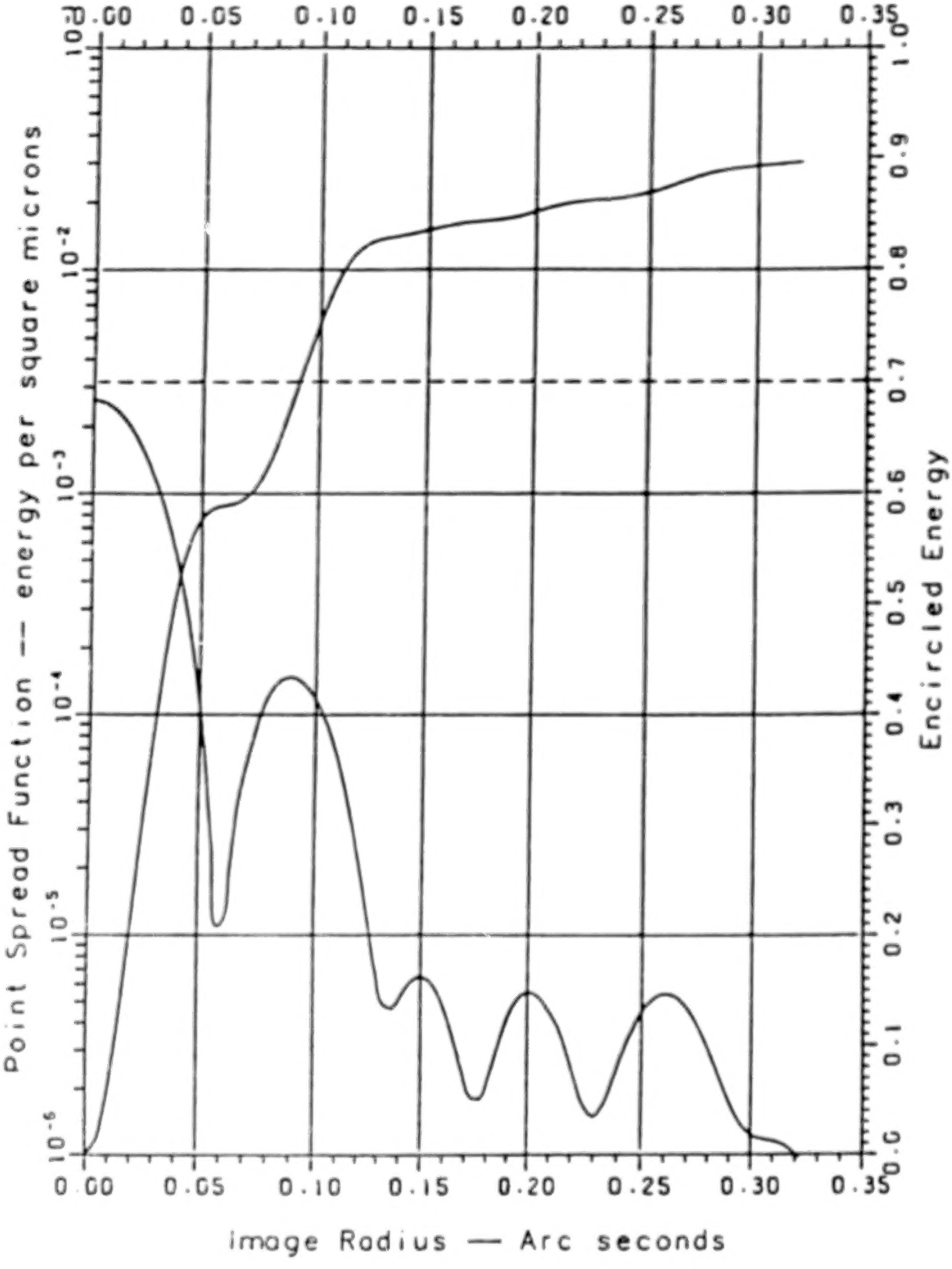


Figure E-2

ST Performance Prediction
Visible wavelength of 0.6328 microns
RMS Wavefront = 0.05 waves at 0.6328 microns wavelength
No Image Motion



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06/17/82

Figure E-3

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65

ST Performance Prediction
Visible wavelength of 0.6328 microns.
RMS Wavefront = 0.05 waves at 0.6328 microns wavelength
Image Motion = 0.007 Arc-seconds

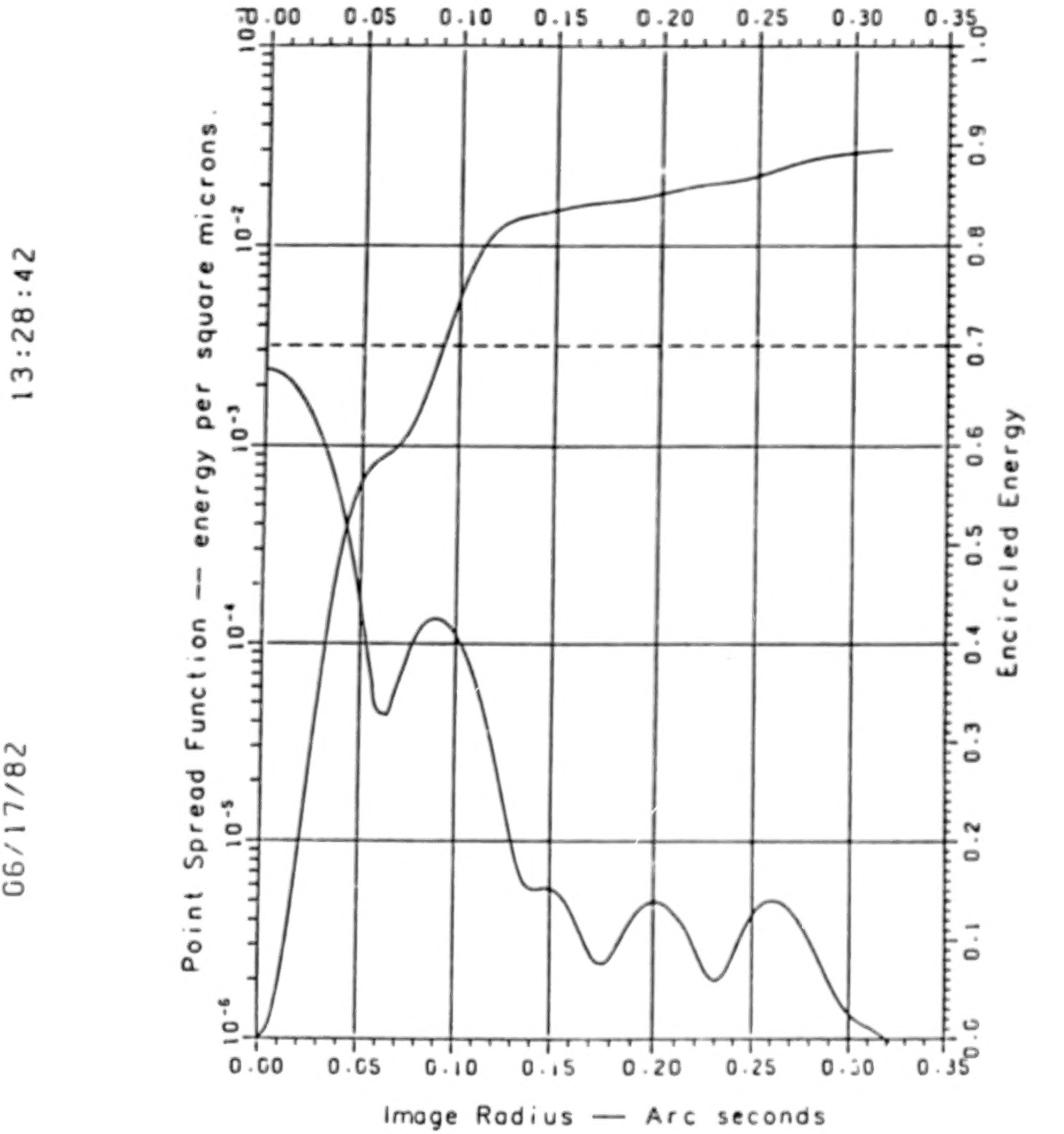

Figure E-4

ST Performance Prediction
wavelength of 0.3500 microns.
RMS Wavefront = 0.05 waves at 0.6328 microns wavelength
Image Motion = 0.007 Arc-seconds

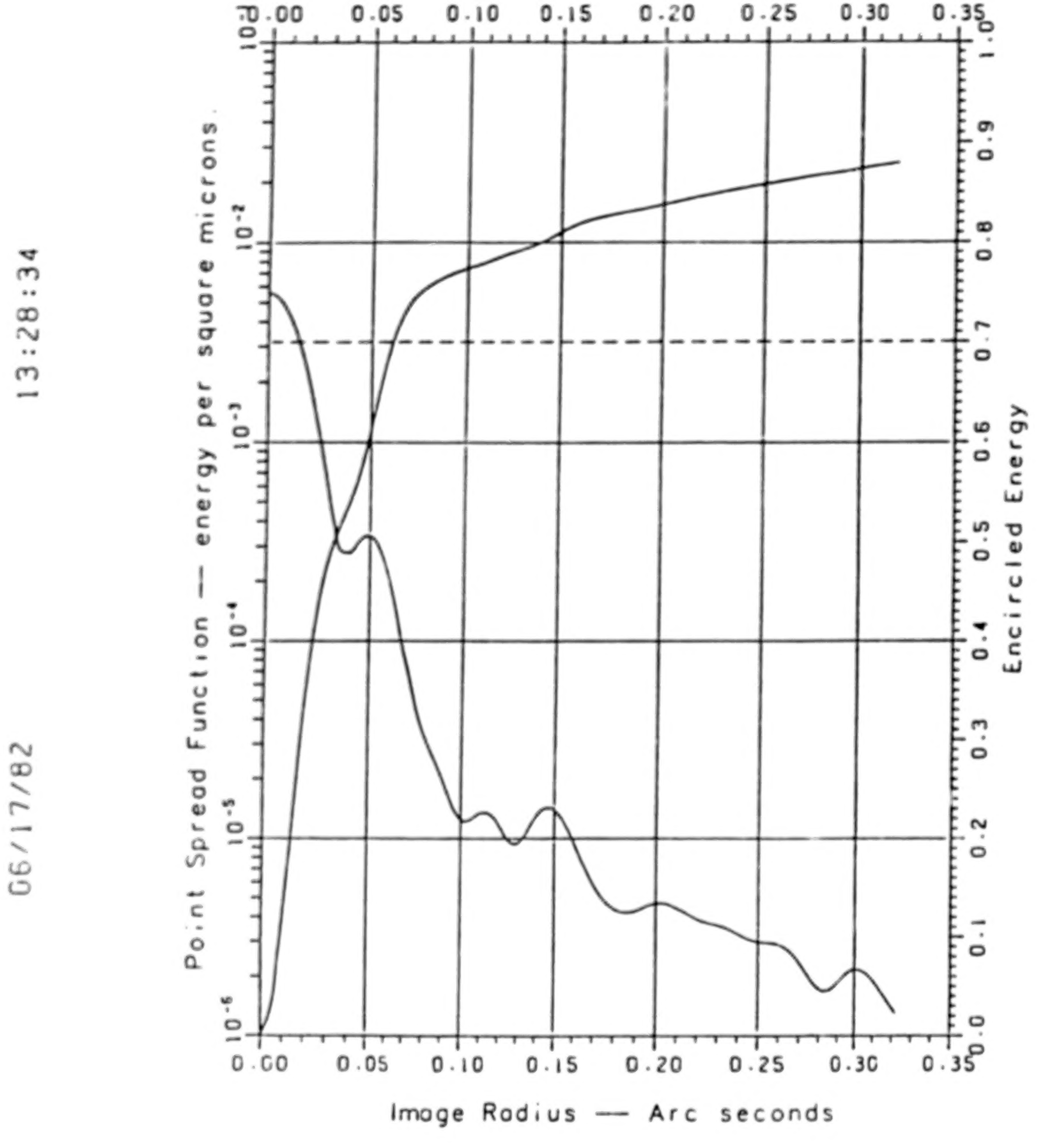

Figure E-5

ST Performance Prediction
wavelength of 0.3500 microns
RMS Wavefront = 0.05 waves at 0.6328 microns wavelength
No Image Motion

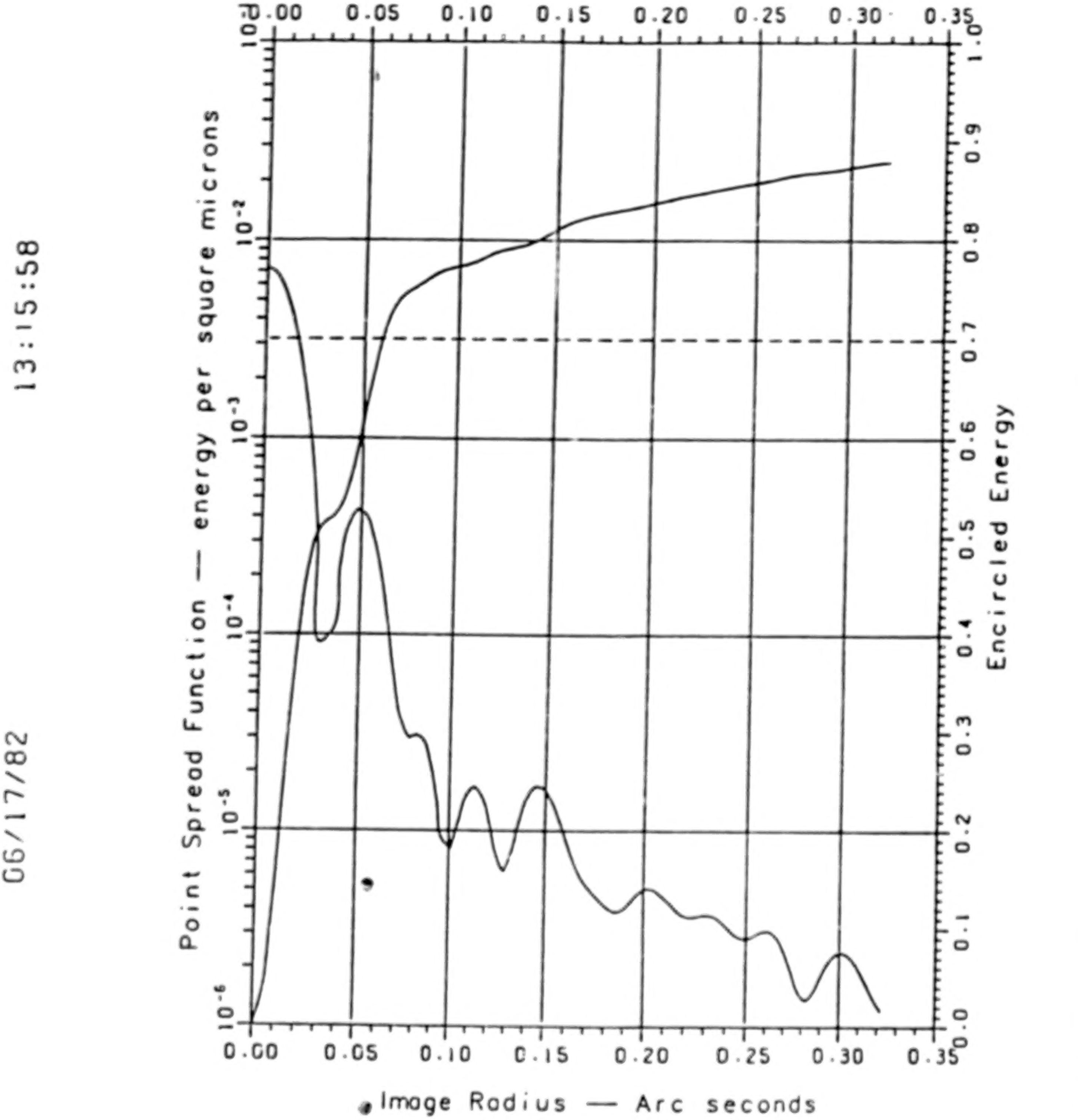

Figure E-6

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48.

ST Performance Prediction
Ultaviolet wavelength of 0.1215 microns
RMS Wavefront = 0.05 waves at 0.6328 microns wavelength
No Image Motion

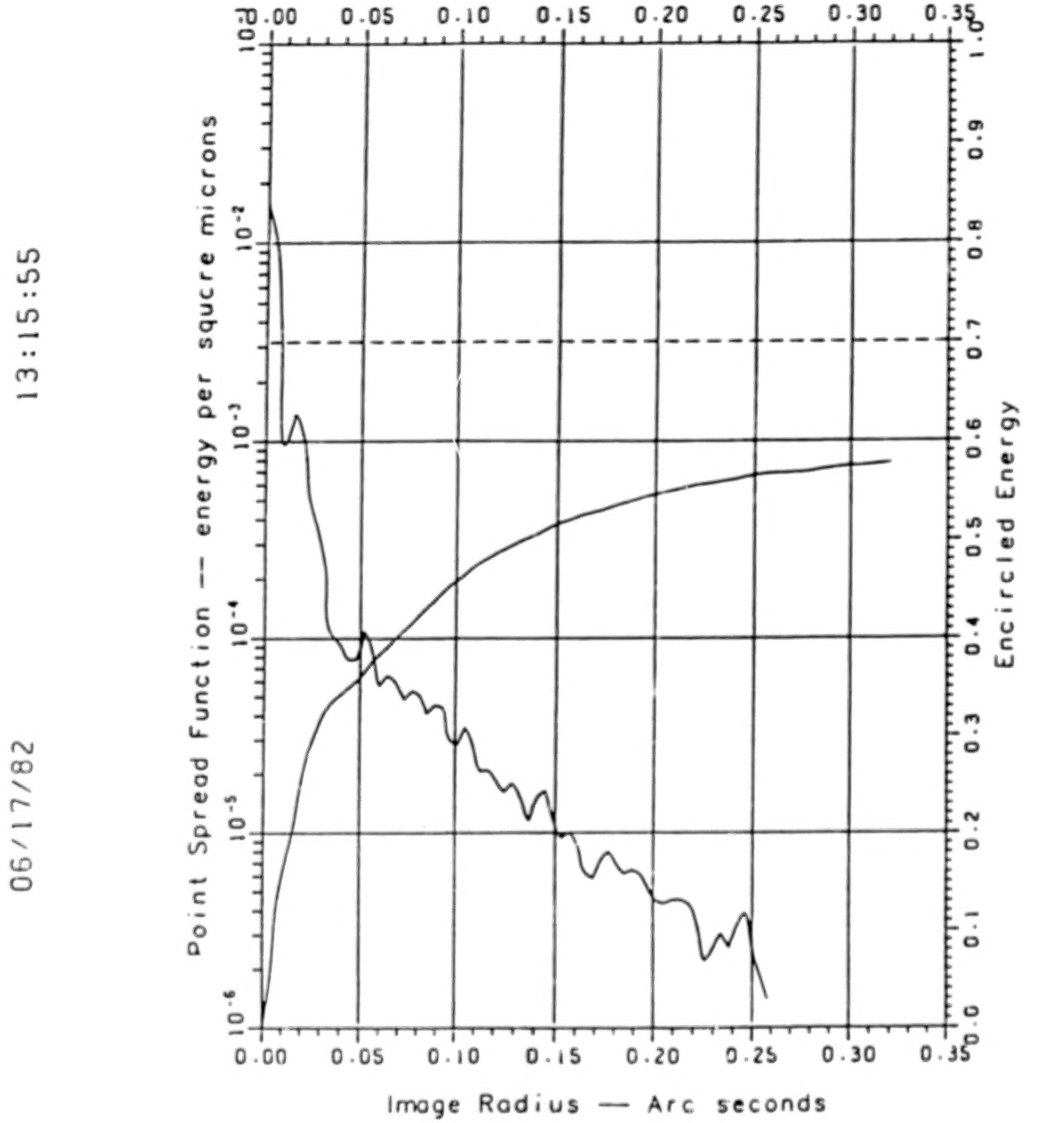

Figure E-7

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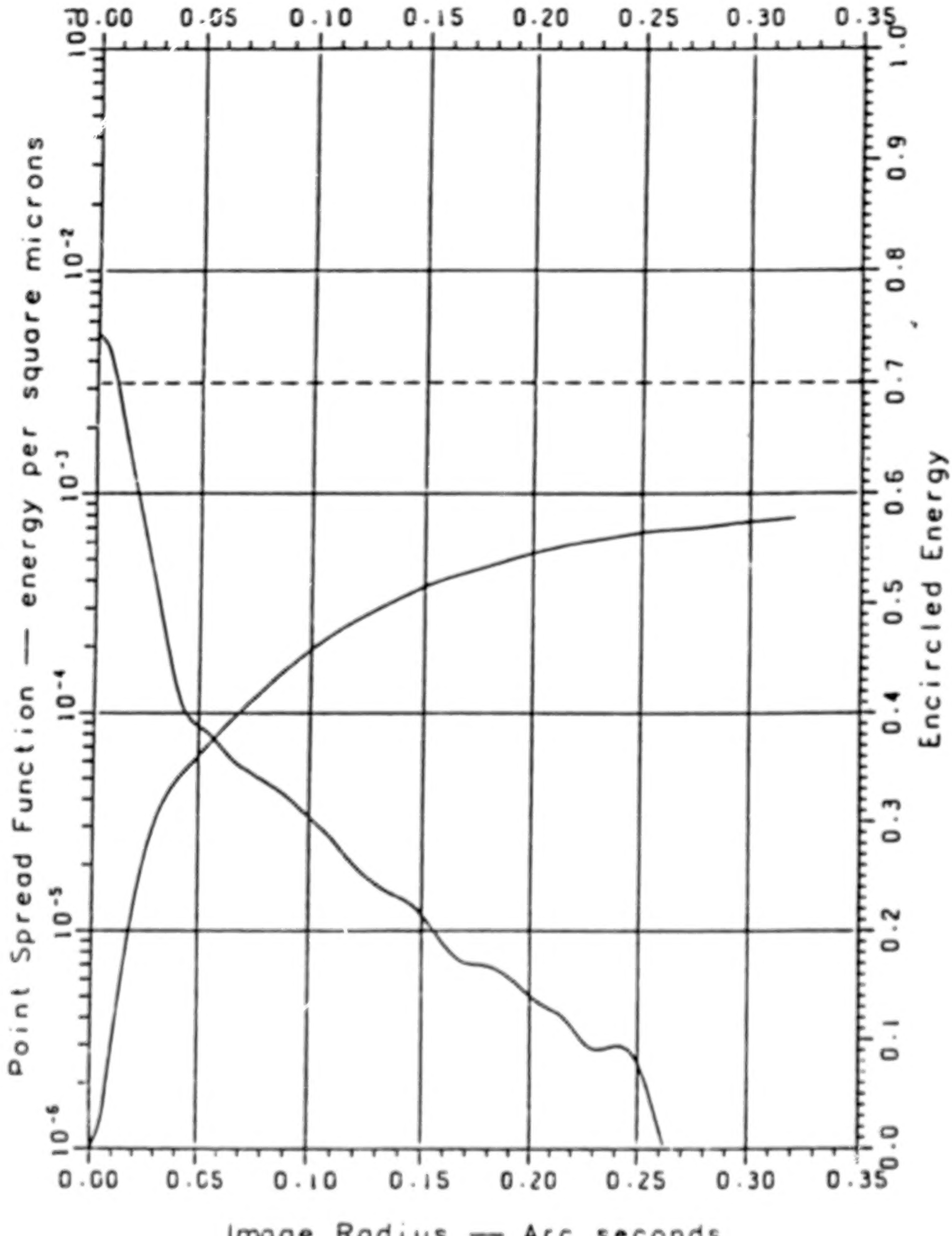
ST Performance Prediction
Ultaviolet wavelength of 0.1215 microns.
RMS Wavefront = 0.05 waves at 0.6328 microns wavelength
Image Motion = 0.007 Arc-seconds



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06/17/82

Figure E-8

ST Performance Prediction
Visible wavelength of 0.6328 microns
RMS Wavefront - 0.075 waves at 0.6328 microns wavelength
No Image Motion

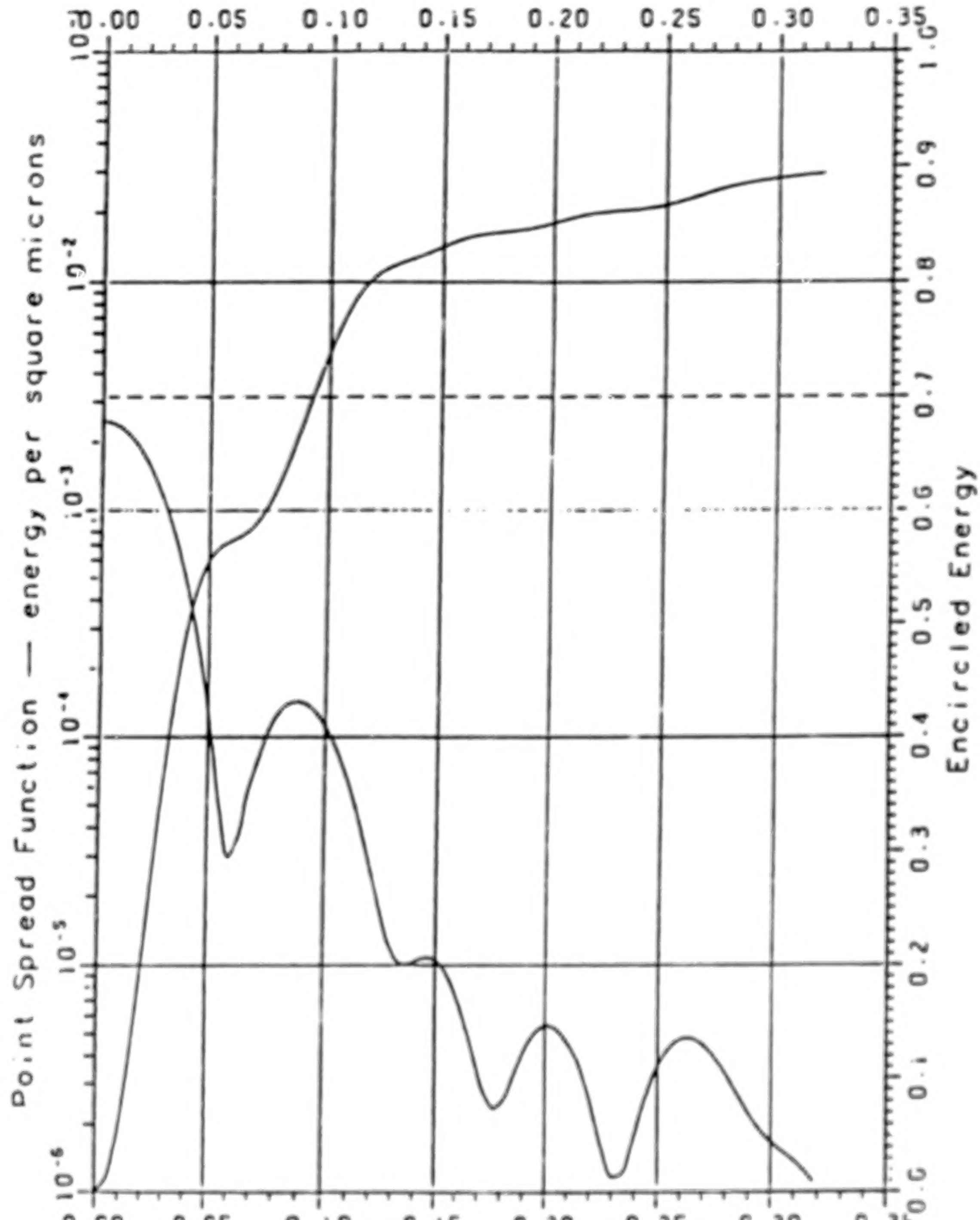

Figure E-9

10:39:21

06/18/82

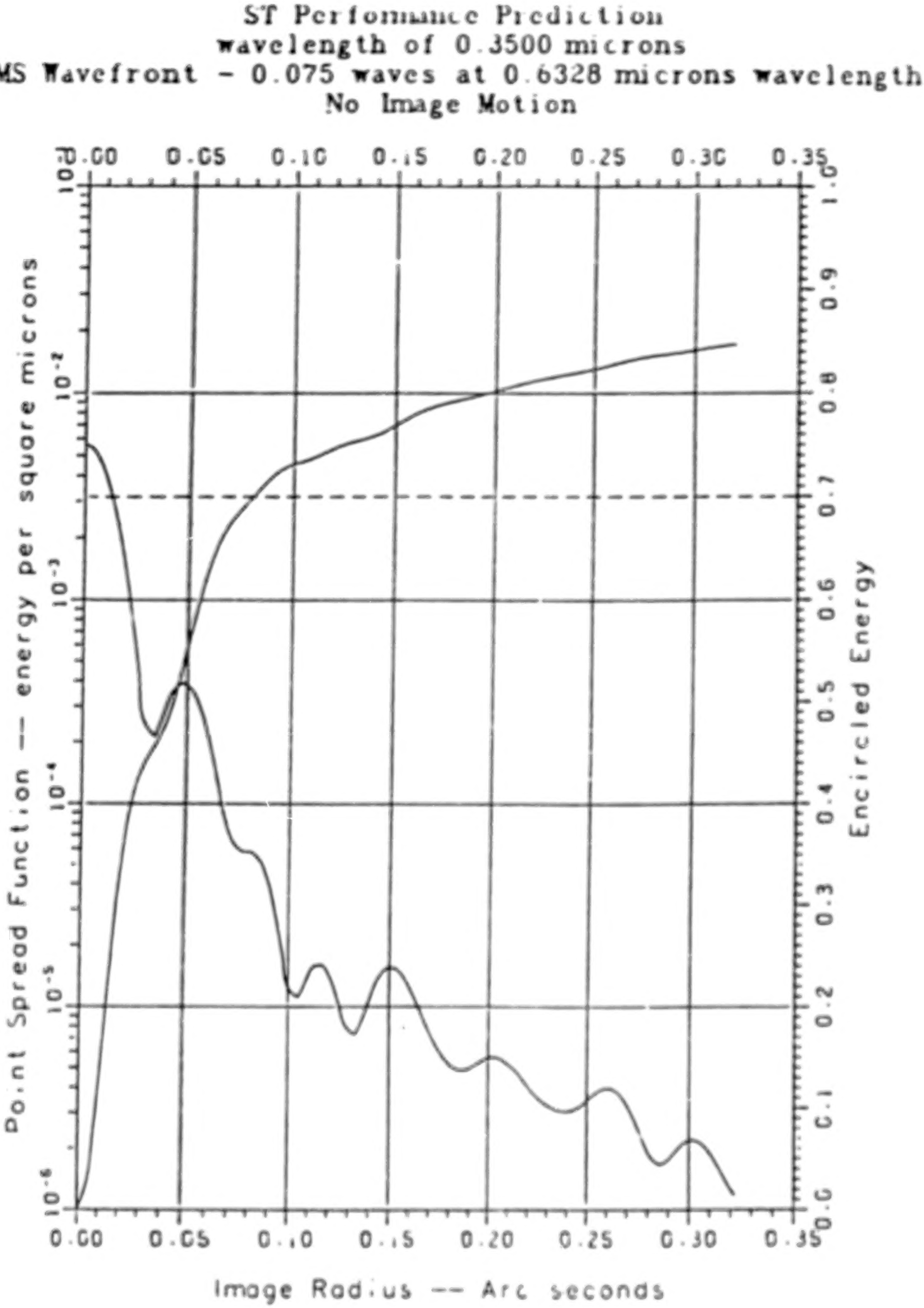

Figure L-10

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ST Performance Prediction
Ultaviolet wavelength of 0.1215 microns
RMS Wavefront - 0.075 waves at 0.6328 microns wavelength
No Image Motion

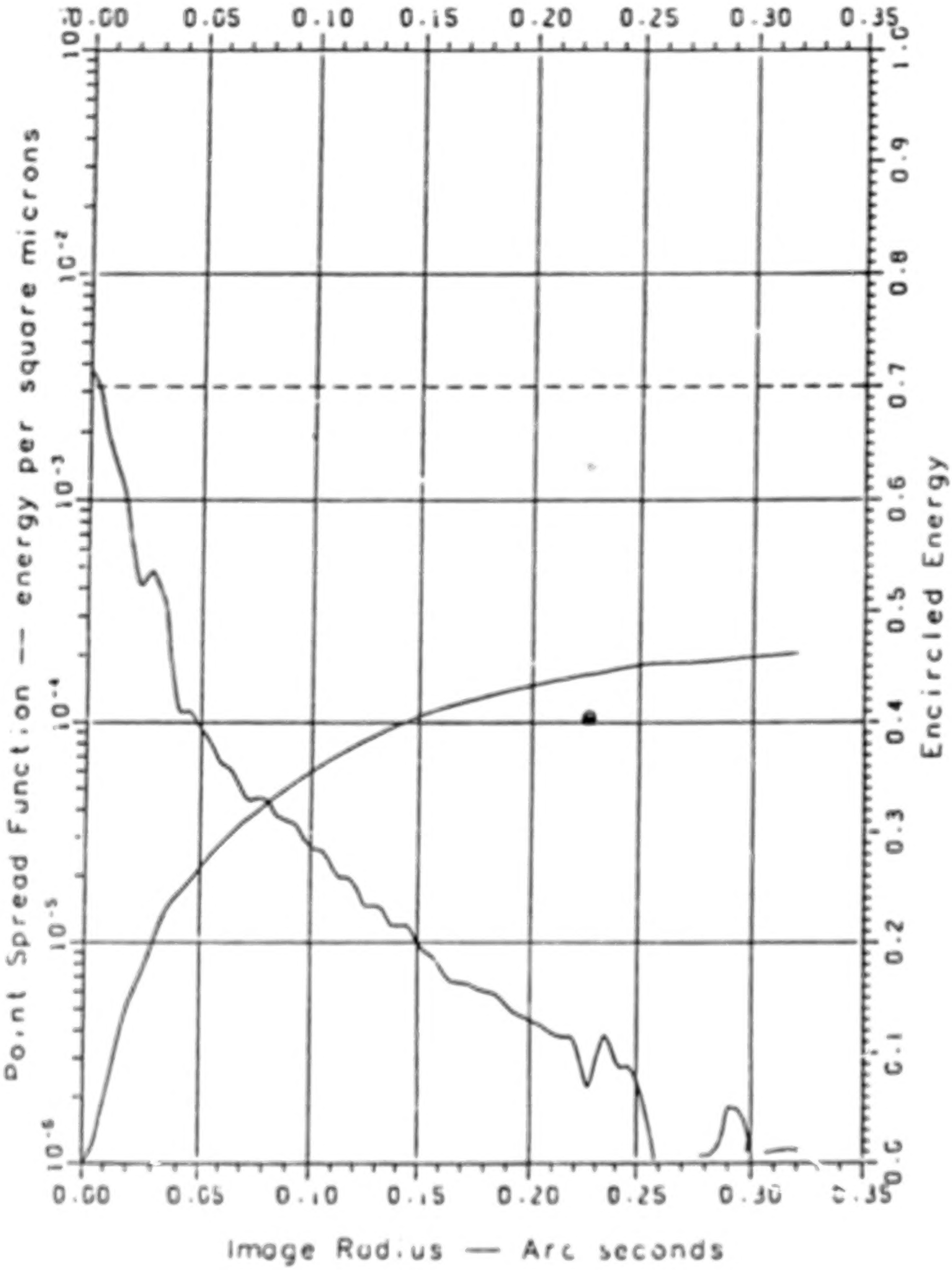

Figure E-11

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10:39:13

06/18/82

ST Performance Prediction
Visible wavelength of 0.6328 microns.
RMS Wavefront = 0.075 waves at 0.6328 microns wavelength
Image Motion = 0.012 Arc-seconds

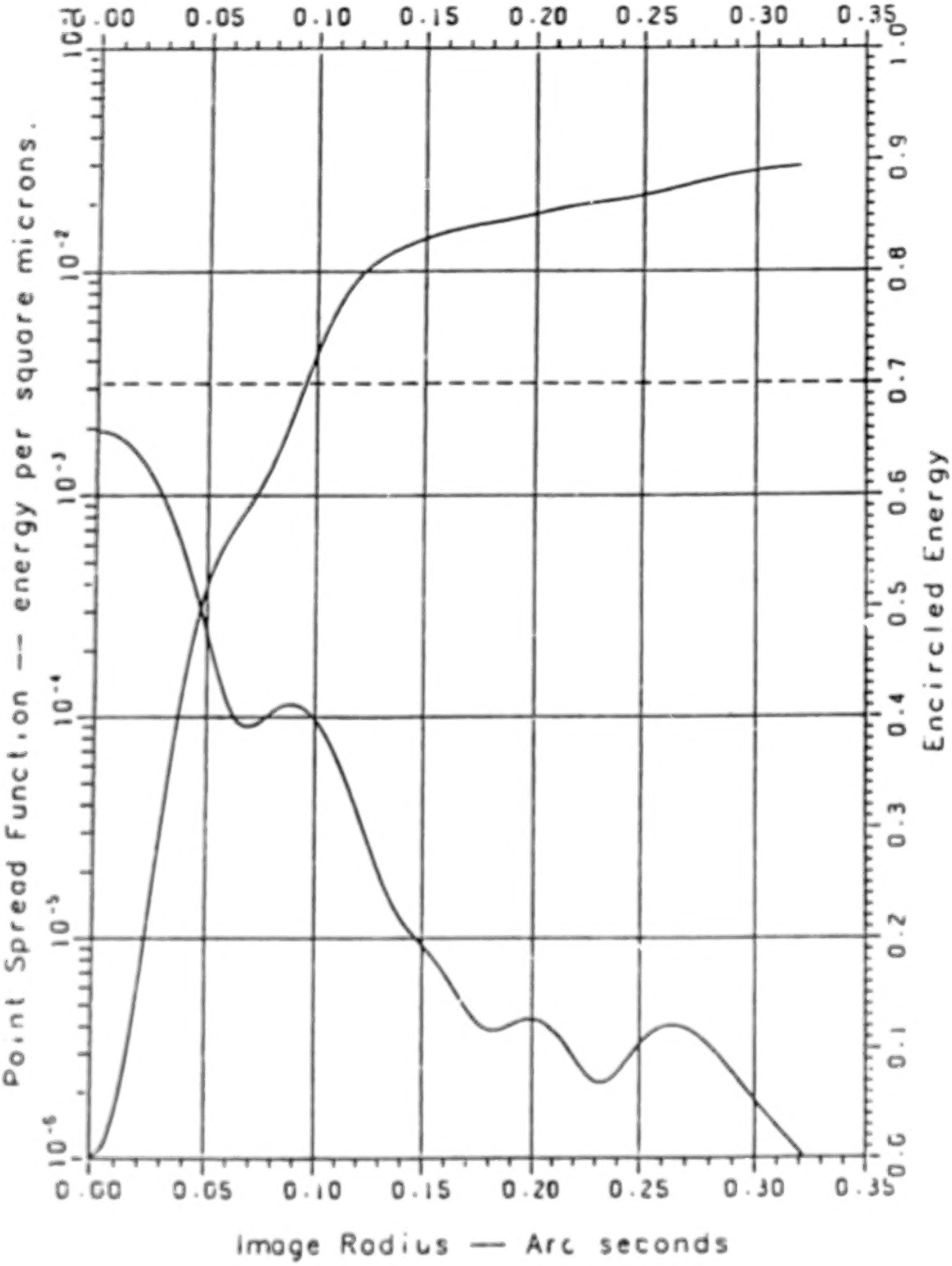

Figure E-12

14:35:48

06/18/82

ST Performance Prediction
wavelength of 0.3500 microns.
RMS Wavefront = 0.075 waves at 0.6328 microns wavelengtl
Image Motion = 0.012 Arc-seconds

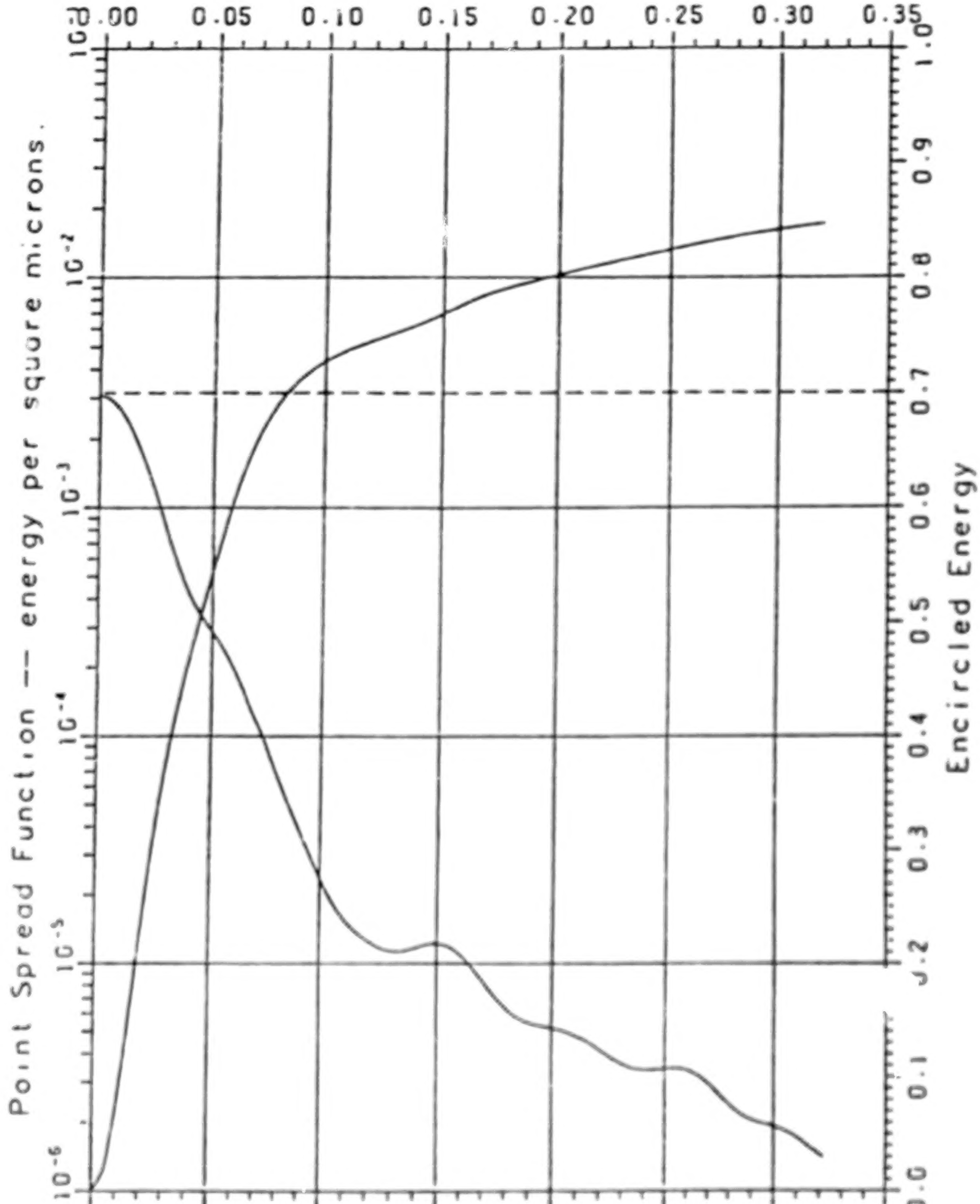

Figure E-13

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14:35:42

06/18/82

ST Performance Prediction
Ultaviolet wavelength of 0.1215 microns.
RMS Wavefront = 0.075 waves at 0.6328 microns wavelengtl
Image Motion = 0.012 Arc-seconds

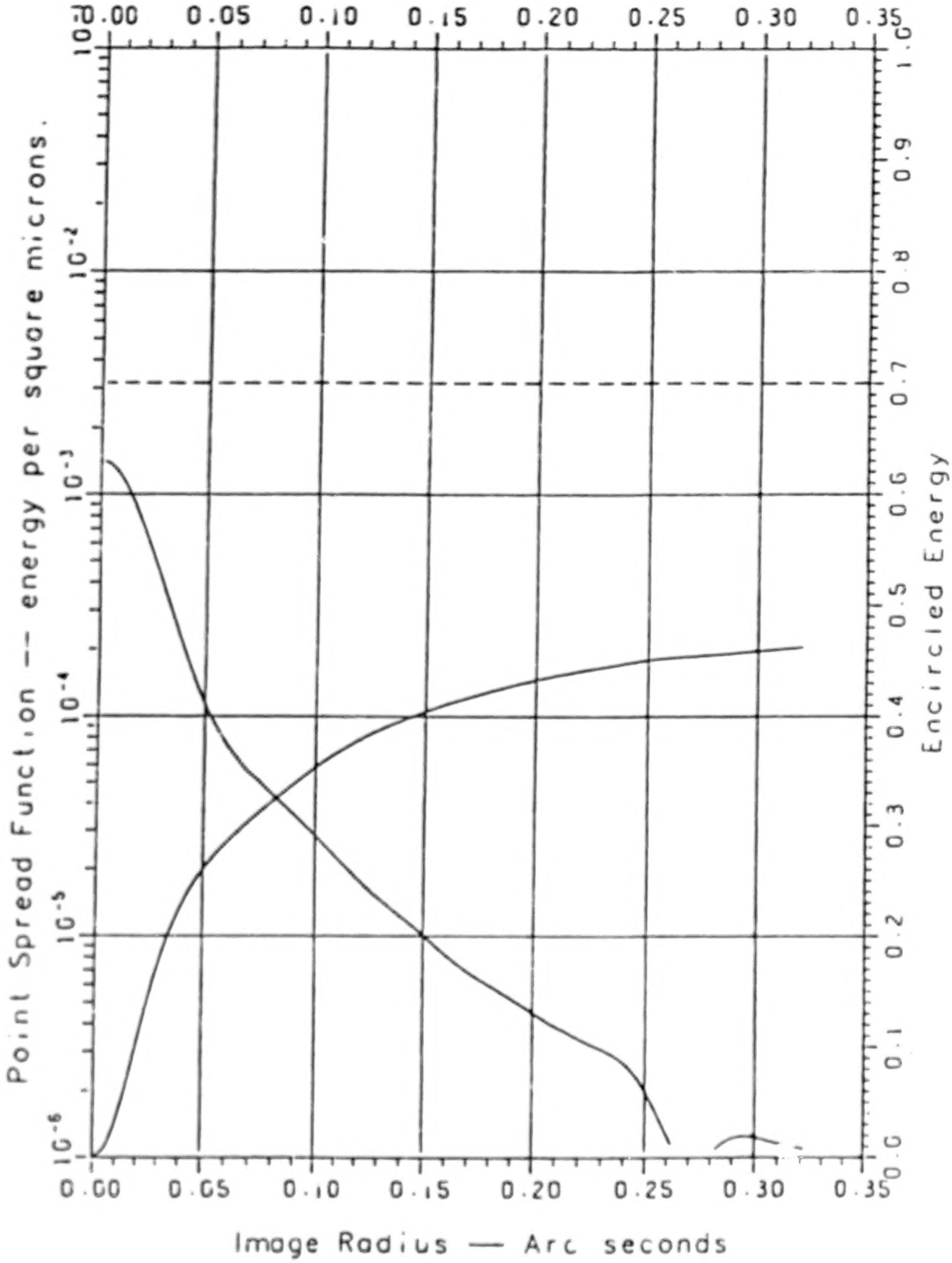

Figure E-14

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END

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